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NGMN Top OPE Recommendations

next generation mobile networks

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Editor in Charge:	Frank Lehser
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Abstract: Short introduction and purpose of document

This document describes use cases, recommendations and solutions to ensure operational efficiency in NGMN networks. The content of this document has been elaborated in the context of NGMN project on Operational Efficiency (P-OPE)

0. PREAMBLE

Setting up and running networks is a complex task that requires many activities, including planning, configuration, Optimization, dimensioning, tuning, testing, recovery from failures, failure mitigation, healing and maintenance. These activities are critical to successful network operation and today they are extremely labour-intensive and hence, costly, prone to errors, and can result in customer dissatisfaction. This project focuses on ensuring that the operators' recommendations are incorporated into the specification of the 3GPP O&M (and similar groups in other standardisation bodies) so that this critical task moves towards full automation.
The overall objective is to provide operators with the capability to purchase, deploy, operate and maintain a network consisting of Base Stations (BTS) and "Access Gateways (AGw)" from multiple vendors.

The NGMN project Operational Efficiency OPE has taken the task to elaborate solutions and recommendations for pushing the operational efficiency in NGMN networks and has produced recommendations on standards and implementations. The NGMN OPE project also influenced strongly the setup of a TOP10 (refer to [16]) document reflecting main recommendations in operational area. This document binds these two sources which are anyhow strongly linked together into one common NGMN recommendation document. The following picture gives a high level view on the relationships of topics and projects which gives the structure of this document.

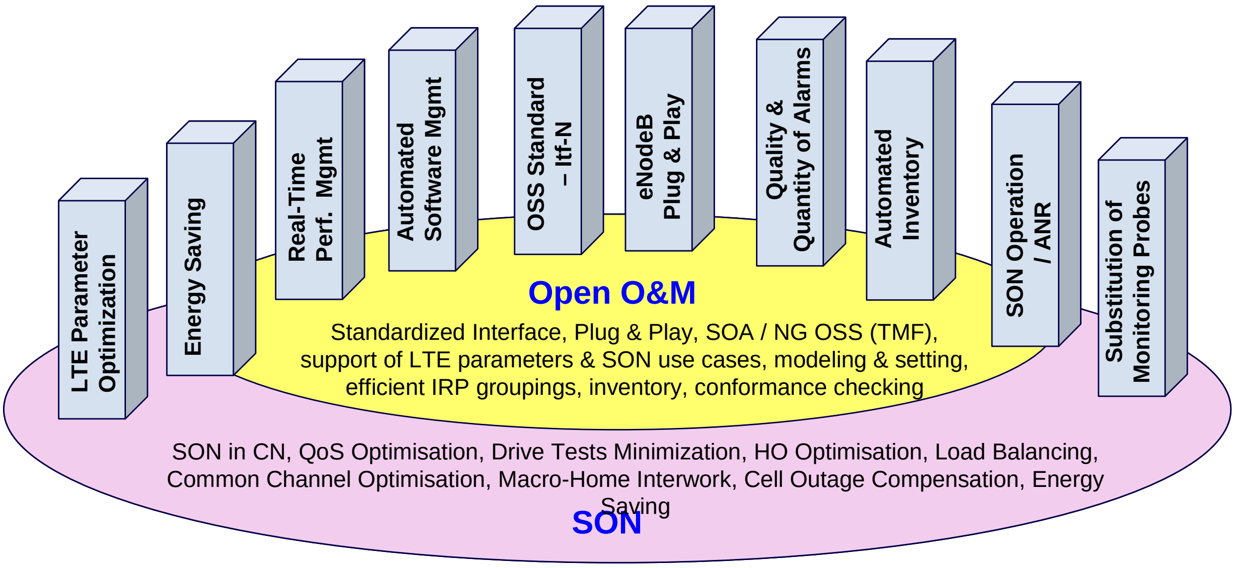


Figure: Relationships OPE projects and former TOP10 topics

General remark on this document: considering the fact that this document is a living one which is naturally to be continuously updated considering newest achievements of standardization and project work possible unbalanced character of this document (some topics might be already detailed some are only touched on high level) might be understood and accepted. This may also lead to the fact that the status of e.g. standardisation in 3GPP is not necessarily on the latest state. Strong focus of this document is to document the needs on operational use cases.

1. QUALITY & QUANTITY OF ALARMS

1.1 Abstract

Today's Telco products are in many cases composed out of different components (e.g. network elements, IT systems, network element managers …). The supplier must ensure that an overall alarming concept for their product has been developed instead of independent alarming from each single component.

The concept must ensure that the quantity and quality of alarms allow efficient incident and problem management processes with a minimum number of operators. A layered approach focusing on service degradation and customer impact should support the fast identification of the relevant root causes to minimize the time back to service. Reasonable prioritizations, documentation of alarms as well as alarm correlation on all levels are the basis.

Network operators are today often faced with alarm floods, alarm avalanches caused by single incidents, wrong alarm prioritization, misleading alarm descriptions, and incomplete maintenance manual (e.g. repair actions).

1.2 Expectation of benefit - saving potential

Well designed alarm concepts for the overall product minimize the number of service outages and in case of failure the time back to service.
Good alarm quality and a minimum quantity of alarms reduce operational costs significantly.

1.3 Recommendations

1.3.1 Overall alarming concept

The supplier and their R&D departments are the owner of the detailed system know-how and are responsible for the overall alarming concept. Today the supplier's development departments for network elements and OSS are working often autonomously in that area. The basis to design an overall alarm concept needs to be established between the different vendor's product lines before the start of development phase.

1.3.2 Alarm quantity

Only alarms that fulfil the quality recommendations and which have an additional benefit to solve abnormal conditions should be forwarded by the NE. Meaningless events must be avoided.

Alarm correlation

To fulfil the quality recommendations and to reduce the event number correlation must be implemented on all levels (network element & element manager). Correlation rules which cover the whole product including all composed components must be part of the product solution and should not be project specific. FM agents on NE level (e.g. IT-systems) should be used to reduce the number of unwanted events.

A further correlation of these alarm data in combination with KPI/PM data is needed to give a clear overview of the service related to the whole system environment.

Number of alarms

- In general per incident there should not be more than 10 alarms on the instance which caused the failure.
- Alarm floods of instances which did not cause the failure need to be blocked in any case.

1.3.3 Alarm quality

Focus on customer and service impact

In incident situations the following question need to be answered by the system alarms, without the need for any additional optional tooling:

"What does this incident mean for the customer and the service at all?"

Prioritization of alarms

Criteria for Critical alarms:

- Total disturbance of the system or significant service impact for customers
- Performance, capacity, throughput restrictions
- Accounting disturbed

Criteria for Major alarms:

- Outage of a redundant component (e.g. outage of a redundant power supply)
- Introduction of retaliatory actions required, to ensure the service availability

Alarm maintenance manuals

Alarm maintenance manuals must contain a clear repair action for the dedicated malfunction.

Wherever possible event-based automated repair actions to solve standard error situations without manual interaction should be implemented, if not already implemented on the Network Element level.

Alarm text

Alarm text should contain description of abnormal condition, probable cause, service impact, root cause and a clear short repair action or reference to online maintenance manual. Meaningless events have to be avoided.

1.3.4 Interfaces

See chapter 8 "OSS Standard Itf-N".

2. AUTOMATIC SOFTWARE MANAGEMENT

2.1 Abstract

Software management applications require today too many manual interactions which cause unnecessary efforts and avoidable problems during implementation of updates.

Distribution and activation of SW and FW to all network elements shall be automated to a very high degree. IT standard software distribution systems or DSL forum standards (TR196) could be taken as guidance.

Minimum Recommendation:

Software management has to ensure that even within large networks the Network Element software updates can be implemented centrally within the maintenance window (e.g. 22:00 to 05:00). Less complexity can avoid failures.

2.2 Expectation of benefit - saving potential

Software Management is from operational aspects divided into the following phases: Preparation, Activation and Wrap-up phase

Preparation phase
Network Element and OSS status has to be checked and software packages must be downloaded in parallel to the Network Elements.

Activation phase
During nightshift the software has to be activated within the maintenance window (22:00 to 05:00) and standard network element status checks need to be executed.

Wrap-up phase
In the dayshift remaining errors need to be solved and remaining tasks need to be finished.
The automatic software management can proportionally reduce the effort devoted to the different operational phases.

2.3 Recommendations

<u>Short Term Recommendations</u>

"NE health-check"
OSS system has to be able to verify automatically that network elements are ready for software upgrade. The health-check (e.g. faulty HW Modules, critical alarms, free disk space) has to be executed during the dayshift to ensure the correct behavior and preconditions of the NE itself.

Automated software download
The software download to the NEs should work in <u>parallel</u> with a minimum of unavoidable manual steps. A result overview list must be provided.

One-click NE software activation
Software activation should also work in <u>parallel</u> with a minimum of unavoidable manual steps. The NE health-check should support also the wrap-up activities for urgent issues.

Automatic rollback
Only if the software activations fail completely an automatic rollback should be initiated.

Long Term Recommendations

SW package is made available on OSS, and NEs are tagged on OMC for upgrade. Policies for software activation are set.
For control via northbound interfaces the recommendations in chapter 8 "OSS Standard Itf-N" should be considered.
All necessary activities (NE-health check, SW download, SW activation, corrective actions) are carried out policy controlled by the software management application.
A final upgrade report is provided that will be used as basis for the final wrap up phase.
It is understood that with the long term approach the operator looses detailed control of each single step necessary for a software upgrade. A policy controlled bulk software upgrade is expected to be less error prone than today's solutions

3. ENERGY SAVING

3.1 Abstract

Energy is a main part of the operational expenses. Thus not only network elements with low power consumption become more and more important but also the temporary shutdown of unused capacity is valuable.

Currently network elements can only be put in stand-by mode using modems or SMS controlled switches managed by separate tools. For an integrated energy saving functionality network elements shall provide a stand-by mode with minimum power consumption and a possibility to switch on and off this stand-by mode remotely via the element management system without affecting the customer (e.g. dropped calls).

An automatic capacity-driven energy saving mode can only be realized in existing networks using higher-level network management systems based on performance data. Due to the delay of delivery of the PM data a restart at short notice cannot be guaranteed. Thus a reliable and riskless solution is currently not feasible. With the help of SON features integrated in network elements and element managers a dynamic temporary shutdown of unused capacity shall be enabled.

3.2 Expectation of benefit - saving potential

The possibility to temporarily switch-off (some parts of) radio access network nodes, e.g. for a given Radio Access Technology (GSM, UMTS) will reduce the operational costs related to power consumption.

3.3 Recommendations

3.3.1 Recommendations on NE / X2 interface

- The network element shall provide an energy saving mode with minimum power consumption allowing a restart of the network element in less than 5 min triggered via the O&M or X2 interface.
- In case a loss of connection of the X2 or O&M interface is detected, the node shall restart without any further trigger.
- The network elements shall be informed about the status of neighbor sites. If additional capacity is needed, neighbor sites in energy saving mode shall be restarted via X2 interface immediately (less than 5 min).
- Energy saving features shall be considered in other SON use cases (load balancing, cell/service outage detection & compensation, mitigation of unit outage).
- Sites in energy saving mode shall be considered in automatic HO adjustment (via X2).
- Non-availability of sites due to energy saving mode (node itself and associated NEs) should not be alarmed by the NE.
- The energy saving functionality shall be adequately expandable to 2G / 3G technologies.

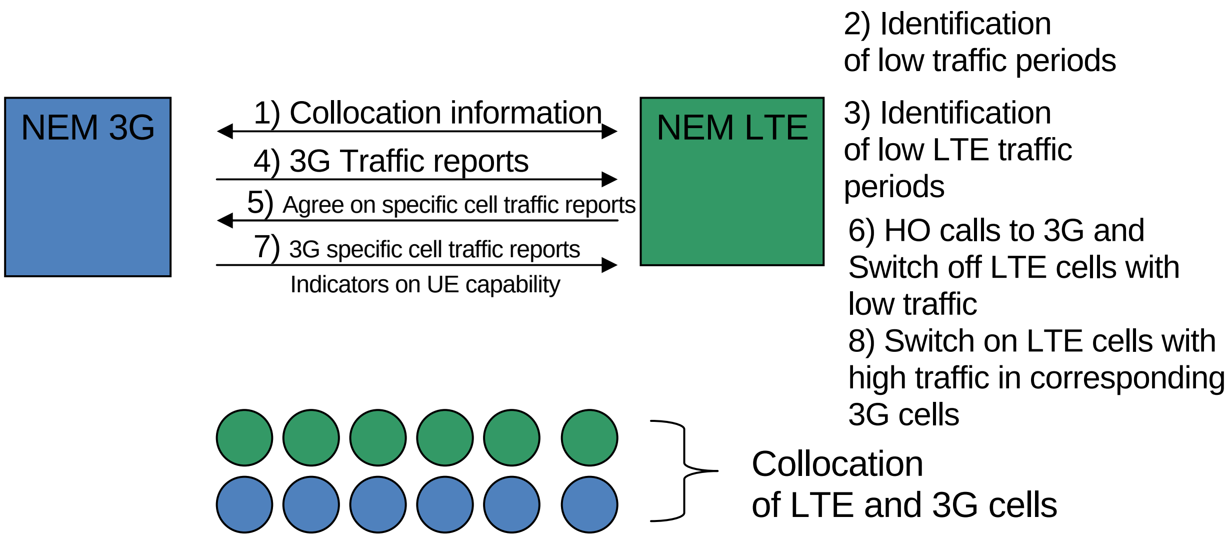
3.3.2 OSS/EMS recommendations

- The energy saving functionality shall be controlled by the element manager. A GUI shall be available to de-/activate a static / dynamic energy saving mode of single or groups of nodes incl. definition of time frames when the feature shall be active.
- The system supports automatic detection of low-load periods as basis for operator or automatic decisions on definition of time frames when the feature shall be active.
- The energy saving functionality shall be supported completely on the Itf-N (BulkCM and / or CLI).
- It shall be possible to configure thresholds and rules of conditions to "switch-on/off" a site automatically.
- The element management system shall have the actual status of the network element at all time.
- The de-/activation of other SON features associated with automatic "switch-off" shall be configurable (automatic HO-adjustment of neighbor sites, load balancing, cell/service outage detection & compensation, mitigation of unit outage).
- A failed re-start of a network element shall be alarmed.
- Non-availability alarms of sites due to energy saving mode shall be suppressed. This applies not only for alarms of the NE in energy saving mode itself but also alarms of connected NEs shall be avoided (e.g. neighbor-nodes, switches, etc., preferably at NE level).

- It shall be possible to identify the designated energy saving mode in performance data (preferably at NE level) in order to consider this in KPI calculations (e.g. cell availability).
- Under the assumption that the "switch off" of cells is only done if a redundant coverage is given by other cells (of e.g. eventually other collocated RAT) the system supports the import and export of traffic indicators from cells to understand the traffic situation in the cells doing the backup. If the traffic is exceeding a certain operator defined load the system ensures that cells in energy saving mode are activated at once to ensure best customer experience with respect to performance and quality.
- The delivery of these traffic indicators shall be in more real-time than PM to ensure a quick reaction on changed traffic situation in the backing cells.
- Provision of capability indicators indicating which RAT active UE in a cell is capable to support. Idea behind is to identify if upcoming traffic in backing layer is dedicated to a UE which can benefit by switching on the LTE cell once again.
- Energy saving features shall be considered in other SON use cases (Load Balancing, cell/service outage detection & compensation, mitigation of unit outage)

3.3.3 Proposed first solution

First solutions shall focus on using redundancy in different RAT layers like LTE and 2G/3G. In the following picture the principle method is described as an example how to switch off LTE cells in case of no load in the LTE cell and waking up of this cell when traffic is indicated in the collocated 2G or 3G cell backing-up the switched off cell. When a cell is switched off the problem is to recognize situations in which the cell should be switched on again: for these appropriate information flows should be established.



Picture 3: Inter RAT ES Scenario

Note on Picture 3: the information flows shown in the picture are seen as logical ones. The assumption is that these flows are realized on a northbound interface with a network management tool between the NEM 3G and NEM LTE.

Note: In a first step the focus is on a centralised ES solution. Nevertheless the requirements are applicable also for other options but maybe need to be transformed appropriately

3.3.4 Recommendations to the Standard

- Standardization of physical layer broadcast channels (SCH/BCH/CRS and RACH) when the eNB has no active UE
- Standardization of PM

- Traffic reports
  - For Traffic reports: real-time character to ensure a quick reaction on changed traffic situation
  - RAT capability indicator
  - Reports on temperature, energy consumption
  - Support on delivery via northbound interface
- Standardization of cell characteristics (geographical foot print) available on northbound to network management level
  - To explore: definition of geographical footprint of a cell (e.g. geographical points defining a line around the rough coverage area of the appropriate cell)
    Background: such information can give NMS ES tools better understanding of situation for decision which cells can be switched off or which cell can do backing of a certain cell. This should be understand as some outlook for future and is not fully analyzed.
- Configuration Management
  - Switch on/off of cells
  - Control of air condition equipment (switch on/off, change control parameter e.g. target temperature definition) (this is considered as an enhanced solution)
  - Setting Power and Tilt via northbound interface
  - Inter-RAT cell change + handover parameters
  - Support on northbound interface

For further details please refer to [9].

4. SELF ORGANIZING NETWORKS

4.1 O&M Support for SON

4.1.1 Abstract

SON and related benefits are seen as an essential economical characteristic of LTE strongly asked for by all operators. As a consequence it has to be ensured that operator keep the control on all new SON functionality by implementation of appropriate policy control functions.

4.1.2 Expectation of benefit - saving potential

An effective O&M support provides operator with network control in SON trust building and learning phase. It allows in all situations that a very good network quality can be assured.

4.1.3 Recommendations

Following generic recommendations are applicable generally to all SON features:

- SON functionality / capability shall have controlled implementation in order to build trust and confidence in automation and avoid massive operational impact
- Network and Management System should provide a general SON Monitoring & Control Application covering policy control, history log and switch on/off functionality per site and cell
- SON centralized and distributed approach must be supported (depending on the SON use case)
- Network and Management System should provide possibility to configure certain break points for SON Operations, allowing the operator for manual intervention to proceed with the logic, or to halt / abort it
- Network and Management System shall be synchronized in real time with SON initiated network changes. Notifications shall also be available real-time via the CM Northbound Interfaces to NMS
- Network and Management System should provide a valuable Reporting Suite for SON activities
- Network and Management System shall fully support SON as defined in 3GPP standards, inclusive CM Northbound Interface 3GPP BulkCM IRP (CORBA or SOAP based)
- Provide an open Northbound Interface for all SON related parameters for interoperability with 3rd party tools
- Network and Management System should be able to request or report the SON related changes for statistical analysis and historical view
- It shall be possible to customize SON policies. On the one hand, there shall be flexibility to adjust the SON functionality to the Operator's recommendations. On the other hand, customization shall be a simple process to minimize the manual effort required.

4.2 Generic Optimization

4.2.1 Abstract

In current 2G / 3G Networks parameter optimization is done manually by analyzing drive-test data and performance measurements. An automated parameter optimization has the possibility to reduce the effort for Network optimization and operations significantly.

4.2.2 Expectation of benefit - saving potential

Network quality and customer satisfaction will be enhanced. Network planning and optimizations efforts can be reduced significantly.

4.2.3 Recommendations

Use cases:

SON should support the automatic parameter optimization for the following use cases:

- Automatic optimization of coverage and capacity related parameters in dependency of related KPIs and thresholds.
- Automatic optimization of QoS and GoS related parameters (i.e. adaption of scheduling and / or RACH parameters) in dependency of related KPIs and thresholds
- Automatic optimization of mobility and handover related parameters (i.e. cell individual offsets, down tilts, Event A related parameters) in dependency of related KPIs.
- Automatic optimization of cells or services in outage based on an unambiguous detection of this outage.

Configuration:

- Optimization for identified parameters can be done within a value range, defined by the operator. Note: operator and supplier providing a SON solution have to consider that the configuration of a value range eventually could restrict SON functionality leading to less benefits of such a solution. On the other hand without such a definition of a value range SON functionality could lead to negative impacts. It is in interest of supplier and operator to find for every use case the appropriate compromise in form of a well balanced implementation to meet the targets of a specific SON functionality and to avoid side effects. For field solutions the best fitting value range has to be found and to be set as vendor and operator specific parameter(s) if the definition of such a range is applicable for the dedicated use case.
- Optimization shall be done with respect to KPIs and parameters not directly related to the use case KPI (i.e. other KPIs shall not become worse than defined thresholds (e.g. handover optimization shall be done with respect to capacity related parameters resp. KPIs).
- Dependency between KPIs resp. definition which KPIs shall be considered in addition to use case KPI(s) shall be configurable by the operator.
- Thresholds for start and end point of parameter optimization shall be configurable by the operator.
- Optimization cycle should be configurable (periodically, event-based)
- Support of centralized / decentralized solution
- Degree of automation configurable by the operator.
    - o Optimization cycle completely automated: yes / no
    - o Automated import of optimized settings: yes / no
- Import / export function of network status with history and fallback solution.
- OSS should provide standardized interfaces to planning tools / processes.

4.3 ANR

4.3.1 Abstract

The SON use case Automatic Neighbor Cell Configuration and X2 Setup is defined in the 3GPP Release 8 standards inspired strongly by NGMN recommendations (see [1]). Based on UE Measurements the eNodeB adapts the NR Table. ANR Algorithm and decision making is located in eNodeB.

Neighbor Relations Table

Neighbour Relation			O&M controlled Neighbour Relation Attributes		
NR	LCI	TCI	No Remove	No HO	No X2
1	LCI#1	TCI#1			
2	LCI#1	TCI#2			✓
3	LCI#1	TCI#3	✓		

4.3.2 Expectation of benefit - saving potential

ANR has the potential to reduce the effort in network planning and configuration changes related to adaptation of adjacent cells that represents one of the most common operations in planning and optimization processes.

4.3.3 Recommendations

- Operator expect from ANR within Intra-LTE, Inter-LTE and Inter-RAT for all handover types:
    - As ideal target: Full substitution of initial planning of relationships based on planning tools;
    - Integration with pre-planning of neighbour relationships based on planning tools;
    - automatic configuration of neighbor relationships inclusive setup of related X2 interfaces;
    - automatic optimization of neighbor relationships
- There shall be fast initial ANR data handling and conditional list implementation, where it is possible to set up a scheme of neighboring cells over multiple Sites with a minimum of UE initiated traffic and customer impact. To face the risks on issues (like lengthy measurement gaps due to ANR or HO failures and call drops due to missing neighbors) several optional features are asked for. It is underlined that these related recommendations shall not put into question that the above SON characteristics of ANR shall be fulfilled.
    - EMS and OSS should provide a general ANR monitoring & control application covering policy control, history log and switch on/off functionality per site.
    - Conditional lists in form of white and black lists as defined by 3GPP shall be stored and configurable within the configuration application / EMS and OSS platform. These lists can be read and configured via the northbound interface in operator's network management level. The ANR functionality informs directly new identified neighbors to the EMS and the OSS.
    - Neighbor cell lists shall be autonomously configured and optimized by the system based on UE measurements according to 3GPP's ANR, with user setting options like: which UE measurements to use for cell list optimization, forbidden adjacency relations, no handover & no remove attributes, etc.
    - ANR functionality is expected in a way that following handover procedure can be done directly after or "on the fly". This means that the time for relationship identification and configuration inclusive setup of X2 is minimized on less than 2 seconds.
    - The system shall support specific ANR measurements and its configuration separated from specific HO measurements to enable early relationship identification. Target of this is to ensure that the relationship configuration time does not endanger the successful following handover.
    - For LTE->3G and LTE->2G neighbor relation configuration some pre-planned information via northbound interface or available information in a Multi-RAT system (like given relations of collocated cells, scrambling codes or ARFCN of likely neighbors) can be used to mitigate side-effects of time consuming UE measurements in an efficient way.
- Network and Management System support for Automatic X2-Setup based on handover-relations.
- Network and Management System to be able to configure / manage "no X2 flag", "no remove flag" and "no HO flag" (as opposed to eNodeB only per 3GPP
- Due to missing standardized ANR functionality for the direction from 3G or 2G to LTE the system shall support neighbor relation planning for these directions. Future standardization to cover multi vendor scenarios is asked for. The exchange of neighbor relation lists from planning tools or other EMS via northbound interface shall be supported. Within the Multi-RAT system of one supplier the different RAT neighbor relation information shall be considered to achieve automatic neighbor relations also for 3G->LTE and 2G->LTE directions.

4.4 Minimisation of Drive Tests

4.4.1 Abstract

Network operators strongly rely on manual drive-tests to collect the field measurements that are needed to monitor and optimize the performance of their networks. Drive-tests require a huge effort in terms of resources and time. Moreover, drive test can be usually only be done in specific areas (e.g. roads), whereas users and traffic are also distributed on areas not accessible for drive-tests (e.g. indoor). Therefore, it will be highly beneficial to automate the collection of field measurements and to minimize the need for operators to rely on manual drive-tests.

4.4.2 Expectation of benefit - saving potential

Drive-tests require a huge effort in terms of resources and time so huge potential is given if typical information can be provided by other methods than by today's cost driving drive tests.

4.4.3 Recommendations

According to the overall technical analysis performed, solutions in support for SDT are feasible and expected in the short term evolution of LTE.
It is recommended that NGMN solutions for SDT shall:

- be able to support both user-plane and control plane architectures, depending on the operator's deployment strategy.
- rely on UE involvement for performing, collecting and reporting measurements to the O&M, for both real-time and non real time-reporting, also providing Location and Time information
- provide efficient handling of a significant number of UEs and the selection of UE based on capability or user profile
- effectively support multi-RAT and multivendor scenarios

4.4.4 Proposal to the standards:

In particular the relevant standardization bodies shall address the following aspects according to the recommendation above:

3GPP

- RAN: protocol extensions for the control-plane architecture (RRC to configure the UE measurements and events and reporting, both for real time and non-real time; network interfaces in order to support measurement collection and reporting in mobility)
- SA5: Itf-N enhancements to support SDT management and to retrieve UE measurements, both for a control-plane and for a user-plane architecture.
-

OMA

- OMA-DM: a new OMA-DM Managed Object to support to support the configuration of measurement, collection and reporting of UE measurement with a user-plane architecture

The solutions should be as much as possible part of the earliest release of Technical Specifications in the relevant bodies. The standardization activity can be scheduled considering the operator's priority related to the use cases. However the principles selected for the SDT baseline solution should be future proof and minimize the impacts of legacy solutions towards future extensions.

For further details please refer to [13].

4.5 HO Optimization

4.5.1 Abstract

The HO optimization considers the self-optimization of the handover parameters like handover neighbor list, neighbor specific thresholds and hysteresis parameters. Therefore, this use case aims to reduce the occurrence of undesirable effects following handovers, such as Too Early HO, Too Late HO, HO to wrong cell, call drops and ping-pong handovers between two cells.

4.5.2 Expectation of benefit - saving potential

In today's networks cell individual setting of HO related parameter often done only in an reactive way: based on customer complaints, triggered by bad KPI and performance measurements or experiences based on drive tests. Beside the fact that all these activities cost resources and time these indicators ring the alarm bell at first at a certain level of problems. With functionality detecting and mitigating the problems very early better quality can be achieved and optimization resources can be used for more complex optimization problems in the network.

4.5.3 Recommendations

In the following recommendations for the areas HO Problem detection, Optimization actions and O&M recommendations for HO Optimization functionalities are given.

4.5.3.1 HO problems detection solutions

For HO Optimizations following solutions are needed:

- Detection of Too Late inter-RAT HO
- Detection of Too Early inter-RAT HO
- Detection of inter-RAT HO to Wrong Cell
- Centralized inter-RAT HO problems detection

These solutions should consider the subclasses of HO from LTE to UTRAN/GERAN and UTRAN/GERAN to LTE. The detection of this case requires:

- The UE to provide information to identify its previous context within RAT when re-establishing the RRC connection in another RAT (RRC Connection Setup);
- A "RLF Indication" procedure from RAT to RAT (involving the Core Network);
- A "HO failure Indication" from RAT to RAT (involving the Core Network);

In order to trigger the "HO failure Indication" at RAT, the "RLF Indication" has to be received at the RAT within a given amount of time since the HO procedure was successfully completed).

4.5.3.2 Optimization action

SON should support the automatic parameter Optimization for the following use cases:

- Automatic Optimization of mobility and handover related parameters in dependency of related KPIs.
- The HOO related functionality have to be harmonised with other SON functionality like Load Balancing, QoS Optimization, Cell Outage Compensation and others.

The implementation of appropriate features and algorithms based on detection features in 6.1.1 is needed. In the following some guidance is given on these vendor specific solutions:

- The HO algorithm considers certain parameters with specific values to decide on HO triggers and start execution of HO.
- For these parameter used in algorithm on MRO or MLB some default settings are defined based on field experiences. The HOO algorithm can set these parameters such that the interaction between MRO and MLB will not degrade the RATs performance.
- Cell individual characteristics like topology or coverage scenarios may lead to problems with given default settings and would lead to cell individual adaptations. These adaptations can be done manually by operator or automatically by SON features which are in focus of this document and related project. The optimization needs to consider the objectives of exceeding a HO failure rate target and minimizing the number of handovers.
- It must be underlined that optimization actions can be also undertaken as a result of statistical elaboration of detected HO failure events.

4.5.3.3 O&M Recommendations

In order to avoid multi-vendor inconsistence, it is necessary to specify the evaluation principles of HO optimization.

- The evaluation metrics and trigger criteria can be defined and customized in OAM interface:
- If the performance does not meet the trigger criteria, stops action; otherwise continues.
- If the performance got worse, reverse action be needed.
- While evaluating, all related performance metrics should be monitored, other performance metrics should not be deteriorated greatly to improve one performance metric.
- If the desired metric got better after optimization action, while others become worse but not enough to trigger action, i.e., it is still in acceptable range, this action should be accepted. Otherwise should be reversed in case the metrics scope within 3GPP are not optimal.
- Some KPIs (defined per neighbour relationship) to be considered for HO optimization performance evaluation could be:
    - Rate of failures related to handover
    - Rate of failures related to handover without RRC state transition
    - Rate of failures related to handover with RRC state transition
    - Statistics of RRC Connection Re-establishment
- Optimization for identified parameters can be done within a value range, defined by the operator. (see also note in chapter 4.2.3)
- Optimization shall be done with respect to KPIs and parameters not directly related to the use-case KPI (i.e. other KPIs shall not become worse than defined thresholds (e.g. Handover-Optimization shall be done with respect to capacity related parameters resp. KPIs).
- Dependency between KPIs resp. definition which KPIs shall be considered in addition to HOO KPI(s) (as e.g. HO Success Rate, Call Drop Rate, Cell individual HO failure rates) shall be configurable by the operator.
- Thresholds for start and end point of parameter optimization shall be configurable by the operator.
- Optimization cycle should be configurable (periodically, event-based)
- Support of centralized / decentralized solution
- Degree of automation configurable by the operator.
- Import / Export function of network status with history and fallback solution.
- OSS should provide standardized interfaces to planning tools/processes.

4.5.3.4 Proposal to the standards

Work should continue in 3GPP (and other standards bodies) to address

- Enhancements to simplify HO failure detection
- Enhancements to distinguish RLF from coverage hole and from too late handover
- Inter-RAT MRO similar to the LTE identified solutions
- New MRO target criteria and their measurements (for example, Call drop/success rates per neighbor during the handover procedure, Number of ping-pong handovers per neighbor cell, Number of RRC reestablishment failure, Throughput before/after handover).

For further details please refer to [11].

4.6 Load Balancing

4.6.1 Abstract

Load balancing promises the usage of given redundancy in the network to move load from the capacity restricted resource to these ones which have free capacity by sharing load information and appropriate reaction on this.

4.6.2 Expectation of benefit - saving potential

Using the given redundancy in overlapping cell areas peak load situation can be handled by load balancing functionality delivering a better customer experience and higher revenue of deployed resources. Secondly necessary capacity based on identified overload can be timely shifted or even avoided.

4.6.3 Recommendations

Load indicators already defined in 3GPP (hardware load indicator, S1 TNL and radio resource status) serve as a baseline for load balancing strategies and implementation. Also, additional load indicators that would provide improved SON capabilities are being considered, such as the amount of resources available for load balancing and non-GBR load information. In addition to that, composite load indicators that would provide complementary information to eNBs are required to provide complete picture on load situation.

In addition to load indicators already defined in 3GPP, for the inter-RAT Load Balancing use cases, NGMN recommends the introduction of new load indicators or the refinement of the existing ones so that:

- Load indicators shall take into account the specificities of source and target RATs so that the load or the available capacity is commonly understood in both RATs
- Load indicators shall accurately reflect the load and be unambiguously interpreted in a multi vendor environment.
- For load indicators report over the north bound interface, load indicators shall be defined such as understandable by 3rd parties SON servers.

In addition to load indicators, reliable protocols and procedures for load information exchange between RATs shall be defined. The protocols shall be defined such as:

- Load information can be exchanged on demand, periodically or based on events. Operators shall be able to configure the type of load reporting to be used based on its own policies.
- Operators shall be able to control the extra signaling generated by the load balancing related information exchange.

In addition, it is recommended that the load balancing solution include the following functionality:

- Load balancing shall have minimal impact on mobility performance while attempting to use a minimum number of handovers or cell re-selections needed to achieve the load balancing.
- Load balancing in mobility scenarios should be coupled with algorithm that automatically adjusts cell individual offset parameter (as per SOCRATES study results)
- Load balancing algorithm in mobility scenarios shall also relay on awareness of type of basestation to decide whether to enforce handover to macro or to pico cells (as per SOCRATES study results)
- Load balancing shall be designed in such way as to increase overall resource utilization in overlayed heterogeneous networks and reduce investment in capacity.

In terms of load balancing management and interoperability, NGMN recommends the following:

- It shall be possible to customize load balancing policies. On the one hand, there shall be flexibility to adjust the load balancing related SON functionality to the Operator's recommendations. On the other hand, customization shall be a simple process to minimize the manual effort required.
- A multi-vendor interface between eNB and O&M needs to be supported to allow for seamless operation in multi-vendor scenarios.
- Provide an open Northbound Interface for all load balancing related parameters within SON for Interoperability with 3rd party Tools.
- It would be desirable to extend the SON functionality to use E2E approach, such that traffic management selection is based not only on load balancing indicators, but also on network topology as to avoid for example MME or SGW relocation in case of intra LTE balancing.

Finally, cell selection and reselection should have the following capabilities:

- Based on the long term traffic behaviour, it should be possible to direct the traffic in advance by a centralized entity (e.g. periodic events such as sports, fairs, etc).
- Cell reselection for idle users should take into account current active user conditions so that if QoS demands increase in a cell it is possible to force cell edge users to camp on strongest neighbour, or to the one that has more resources available.

4.6.3.1 Proposal to 3GPP

It is recommended that 3GPP include the following in the standardization effort:

- Complete the standardization work on load indicators to enable multi-vendor and multi RAT support for load balancing
- Complete the standardization work on load indicators to enable reliable load information exchange in a multi RAT, multi vendor network configuration
- Extend automatic neighbour relationship capability to include awareness of type of basestation (macro/pico/femto) so that:
  - handovers to macro cells are enforced when UE speed exceeds certain threshold
  - handovers to pico happen when UE speed is low and when there is spare pico capacity
- Add capability to selectively offload individual users between 3G/4G RATs based on the decision policy.
- Standardize network management to/from PCRF interface so that operator policy can operate seamlessly in multivendor environment.

4.6.3.2 Offload to non-3GPP networks

The implementation of multi-access networks represent an additional opportunity for Service Providers to offload traffic from 3GPP to non-3GPP networks (e.g. to an IEEE 802.11 / WiFi network). Traffic offload in this context could be seen as an additional Load Balancing 'Use-Case' that leverage many of the recommendations addressed in this document which may possibly be enhanced to address.

3GPP network load indicators to be used as 'offload' triggers

- 'Offload' functionality
- 'Offload' management in a 3GPP multivendor environments (including policy, SON)

The question of whether there is interest to include 'offload to non-3GPP networks' within the scope of this project is identified as an 'Open Issue'.

For further details please refer to [12].

4.7 Cell Outage Compensation

4.7.1 Abstract

It has to be separated between detection and mitigation.

Cell Outage Detection: 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). The **Goal** is that automatic system functionality detects sleeping or poor performing cells.

Cell Outage Compensation: The network is being reconfigured to compensate the loss of service in the respective area. It is ensured that in surrounding area of cell in outage the cells which are not directly involved in COC activities significant quality indicators like call drop rate and average throughputs are not negatively affected. When the failure has been removed an autonomous reconfiguration shall take place. The **Goal is:**

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 using redundancy in the network.

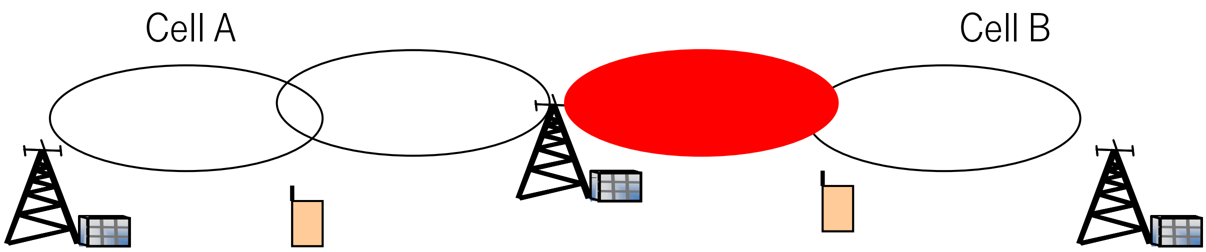


Figure 1: Outage of a cell

Notes
The network compensation could be:
1. Optimization of RF parameters of neighbour cells to mitigate outage e.g. adaptation of power, sub-channels or antenna parameters like e.g. tilt
2. Neighbour lists shall be adapted.
3. Traffic may be shifted to 2G, 3G when handing over in defective cell.

4.7.2 Expectation of benefit - saving potential

Revenue loss of cells or services is avoided. Further customer impact is minimized in case of losses. Maintenance activities can / maybe shifted to planned maintenance time periods with following cost savings.

4.7.3 Recommendations

- The network element can, at the lowest layer, consolidate all available information (alarms, measurements, traces, UE information neighbour cell information, etc) and create a meaningful alarm that indicates a service affecting problem.
- Data is provided to a centralized entity that gathers all necessary information from the networks (e.g. alarms, measurements, traces, PM data, probes, neighbour cells, UEs, eNB heartbeat) and consolidates this information to generate structured information on the service state in each individual cell.
- The centralized entity is multi-vendor capable in that it is possible to connect elements from different suppliers to this entity with no consequent restriction in functionality.
- Service related problems in the network are detected and alarmed.
- It is possible to automatically initiate consequent policy-controlled actions such as automated power down and/or traffic blocking of a sleeping cell, Alarm to Operator. It must be possible for the operator to create related policies.
- The System autonomously compensates for network problems resulting in cell failures. The failure consequences are minimized and the reaction time for the operator can be relaxed.
- In compensating for these failures, the System interfaces to 2G and 3G network for automatic Inter-RAT (I-RAT) neighbour configuration. Handovers in affected cells of 2G, 3G and LTE technology shall be prevented. New handover relations in both, 2G, 3G and LTE, are configured to mitigate the failure consequences.
- Additional parameters such as transmission power and antenna settings are also automatically adjusted.
- In the event of a higher level network element (on which low level elements such as the eNodeB are dependent) failing or becoming unavailable, service outages can be avoided by an appropriate automatic re-parenting of the lower level nodes to other available higher level network elements.
- In doing so, QoS analysis is applied to manage pooling and load sharing activities.
- Automatic healing or mitigation mechanisms for several failure classes are in place, decreasing operational effort and mitigating the consequences of unit failures. Node resources are re-configured autonomously and optimised.
- Fault management and correction is simple and to a significant extent automated, supported, for example, by a correlation function. Parameters such as correlation rule data must be configurable by the operator. Consequent automated actions must also be configurable by the operator.

- During operation of the System, it may be required to add or remove hardware to or from individual entities or groups of entities (for example, an eNodeB or group of eNodeBs) comprising the system, and it may also be required to increase or decrease the capacity of these entities.
- It is required to carry out these changes with:
  - As few site visits as possible
  - As little human intervention as possible
  - Where human intervention is required, only minimum technical skills shall be used
- Automatic Optimization of mobility and handover related parameters (i.e. cell individual offsets, down tilts, Event A related parameters) in dependency of related KPIs.
- Automatic Optimization of cells or services in outage based on a unambiguous detection of this outage.
  Implementation of rule based switch towards planned configuration sets for defined outage scenarios shall be supported by the system.
- The inventory related instances in network management level "NetworkInventory" (reflecting HW and configuration status) and "ServiceInventory" (reflecting service level) provide standard interface to an instance "CellOutageCompensation" so it can retrieve comprehensive (multi-vendor) network view and information about services to be able to calculate the service impact of reconfiguration processes.
- NEMs should provide interface which would enable an instance "CellOutageCompensation" to orchestrate the reconfiguration process. This in particular should enable the instance "CellOutageCompensation" to define conditions/limits for reconfigurations which can be performed by NEM.

Proposals to the standards:
Short-term:

As discussed in chapter 5.2 the standardization of simple centralized solutions is recommended. This centralized solutions may be also the basis for concept development of more distributed functionality.

Standardisation includes:

- Standardisation of information data to understand the outage (Outage Detection)
  - Alarms
  - PM
  - Trace
  - In general: all information to retrieve comprehensive (multi-vendor) network view and information about services
  - Real time behaviour for getting information is required.
- Standardisation of configuration management to support Outage Compensation as e.g.
  - HO related configuration
  - Power settings
  - Tilt (and other antenna parameter) settings
  - Real time behavior for configuration is required.

Some further details are discussed in chapter 5.2.

Long-term:

Analysis of more complex solutions as given in SOCRATES and E3 projects. Standardization of needed functionality is topic of further investigations.

For further details please refer to [7].

4.8 Common Channel Optimization

4.8.1 Abstract

The main aim of this project was to consider SON functionality to optimize the parameters of DL and UL common channels based on UE and network measurements of the common channel performance.
A number of UE measurements for assessing common channel performance were identified and also the parameters of common channels which could be optimised by the SON function were identified.

The preferred architecture was also discussed during the course of the project with the overall conclusion that the most appropriate architecture is related to the use case under consideration.

4.8.2 Expectation of benefit - saving potential (CAPEX/OPEX)

The main benefit of this SON functionality would be to improve the chance for UE to be reached in Idle mode and for UE to access the network from Idle mode. In so doing, the overall user experience of 'coverage' is improved without excessive OPEX to ensure that common channel parameters are correctly set.

4.8.3 Requirements

NGMN recommends that SON solutions for common channel Optimization are implemented according to the following principles.

- It is preferable to perform optimization of DL common channel parameters for a group/cluster of cells rather than for each cell in isolation.
- It should be possible to independently optimize parameters of each common channel. However, it is not precluded that parameters of several common channels are optimized simultaneously by the SON function.
- The basic parameter which the SON function should be able to adjust for all common channels is the transmit power. It is recognized that antenna tilt variation would generally affect performance of all common channels (both uplink and downlink) and hence should not be adjusted by automated functions for optimizing any individual common channel.

The architecture considerations as follows for the definite use cases:

- RACH Optimization: For RACH Optimization, it is obvious that the eNB can perform its Optimization independently of the Optimization performed by neighbouring eNBs, hence, it was concluded that a distributed approach whereby the RACH Optimization algorithm resides in the eNB is more appropriate.
- DL Common Channel Optimization: in [x]?? reasons are provided for choosing a centralized algorithm for common channel optimization on a slow basis.
  In addition to the slow adaptation, it might also be necessary to optimize the DL common channel parameters in a more dynamic way to adjust to sudden changes in the radio propagation environment. For such a dynamic adaptation, it seems more appropriate for the SON function to be localized in the eNB i.e. for a distributed approach to be used.

Proposal to the standards:

- 3GPP is requested to specify the UE measurements for minimization of drive tests in TR 36.805 in such a way that they are re-usable by SON functions for common channel Optimization.
- 3GPP should facilitate the exchange of relevant information (identified in this deliverable) between eNBs for the purpose of common channel optimization using a distributed architecture approach.

For further details please refer to [8].

4.9 Interactions between Home and Macro BTS

4.9.1 Abstract

The main aim of this project was to look at techniques for interference management between HBTS and MBTS with particular emphasis on the use case where UE is connected to a MBTS but under the coverage of a non-allowed HBTS.
The project also briefly looked at Mobility Robustness Optimization and Load balancing between HBTS and Macro BTS based on techniques identified for the macro network as part of the OPE project.

4.9.2 Expectation of benefit - saving potential (CAPEX/OPEX)

It is expected that macro BTS will be able to control the level of interference introduced by non-coordinated deployment of HBTS without the need of operator involvement in reducing increased interference level from user deployed HBTS. The SON functions identified as part of this project will allow automatic adjustment of the HBTS transmit power to improve the interference level experienced by macro UEs and also the automatic distribution of the cell's physical resources to avoid interference between HBTS and MBTS. OPEX will be reduced by the need of less frequent intervention by the operator to resolve service degradation caused by HBTS interference on the downlink and HUE interference to HBTS on the UL.

It is also foreseen that the SON functions described in the deliverable will allow the operator to perform service-interference tradeoffs in areas of shared carrier deployment of HBTS and MBTS.

4.9.3 Requirements

NGMN recommends the support of the UE assisted downlink power control solution as a basic solution for downlink interference mitigation.

In addition, the support of the following solutions is recommended for DL interference mitigation:

1) Fractional Frequency Reuse and Subframe Reuse
2) Partial co-channel deployment

For UL interference mitigation, the following solutions are recommended:

1) Noise Padding
2) Fractional Frequency re-use and Subframe Reuse

Hybrid Interference Management

It is recommended that for the case the HBTS is only providing paging services, HBTS configures UE to make measurements on neighbour cells (including HBTS) and use the measurement report as follows:

1) to set the DL transmit power from HBTS so as not to cause excessive interference to MUE
2) To provide MBTS enough information so that it can control the UE UL transmit power to avoid excessive MUE UL interference at the HBTS.

For the case HBTS provides data services, a basic solution is to rely on the existing handover procedure to avoid excessive UL and DL interference.

Load balancing between HeNB and macro eNB: No recommendation on the solutions could be made.

Mobility Optimization between HeNB and Macro eNB: RLF indications for macro BTS to macro BTS handover are also applicable for macro BTS to HBTS handover.

Based on outcomes of SOCRATES study into HeNB handover optimization it is recommended that SON algorithms focus on the automatic adjustment of the CIO parameter and take into consideration UE speed and cell load.

4.9.4 Proposal to the standards

It is recommended that 3GPP specify the following for each of the recommended solutions:

1) UE assisted DL Power Control
    a) Signalling of power down indication
    b) Signalling of UE MRM from MBTS to HBTS

2) Fractional Frequency Re-use and Subframe Re-use for DL interference mitigation
    a) Negotiation/signaling of resource partition between MBTS and HBTS
    b) Power down indication for a set of Resource Blocks and Subframes

3) Partial Co-channel Deployment for DL interference mitigation
    a) Negotiation of frequency partitioning between MBTS and HBTS i.e. HBTS system bandwidth

UL interference mitigation

Noise padding

a) Exchange of maximum noise figure allowed and maximum transmit power for UE and/or overload indicator (backhaul or OTA)

Fractional Frequency Re-use and Subframe Re-use
b) Negotiation/signalling of different Resource Blocks and/or subframes between MBTS and HBTS
c) Signalling of MBTS to all HBTS in its coverage about resources reserved for use by HBTS
d) Indication by MBTS of resource blocks and/or subframes being used by aggressor MUE so that HBTS can avoid using these RBs and/or subframes.

Hybrid Interference Management
a) Measurements of neighbour cells to allow HBTS to set correct DL transmit power (FFS if existing measurements are sufficient)
b) Signalling of UE measurement from HBTS operating in hybrid access mode to MBTS to control UE transmit power.

For further details please refer to [10].

4.10 SON in CN

4.10.1 Abstract

The operator use cases in RAN as well in CN are categorised into following groups:

- Planning
- Deployment
- Optimization
- Maintenance

The objective of this chapter is to provide generic use cases covering especially CN nodes as e.g. MME.

The following main use cases are seen in CN area:

- Plug'n Play support for eNB deployment by CN nodes
- Plug'n play installation of CN nodes
- Load balancing in CN and between eNB and CN
- Operational use cases like improved performance monitoring, Configuration Management, Inventory, SW management and others

4.10.2 Expectation of benefit - saving potential

SON functionality is very promising for RAN because deployment, optimization and maintenance are strong cost driver with growing number of entities. For core network nodes significantly lower resources must be spent so that possible savings are lower. Additionally also the criticality in case of outages is significantly higher so that operators tend to envisage more control for core network functionality.
But this can also be seen as some argument for SON in CN because tested and trustful automatic functionality may also increase availability of nodes. Generally SON is also seen as potential approach for CN to enable improved quality and /or cost savings.

4.10.3 Recommendations

4.10.3.1 Proposal to the standards

In the following some areas are listed it seems beneficial to improve standardization.

- Further standardization of S1 and X2 auto establishment. Especially transport and security related configuration is strongly operator and provider dependent today so that standardization could minimize options and lead to further cost efficiency.

- Load balancing: load balancing between MME, MME and P-GW, eNB and MME.

- Improved understanding of situation in CN nodes based on standardized performance measurements and indicators on the northbound interface between NEM and NMS.

- Support of standardized deployment scenarios of single CN nodes like MME in a given cluster. Consideration of eNB allocation, relations to other CN nodes and transport & security issues. Management support via the northbound.

- Standardized O&M for CN: examples are SW management, Pool Management, support of PM and CM for important use cases. Consider specific IRPs for core network nodes.
- Enable one common view on the network including RAN and CN nodes in multi vendor scenarios and impact model on services. Enabler for this common view is a standardized northbound interface and supporting functionality in RAN and CN NEM and on NMS level. Standardization shall follow recommendations on NGOSS.
- It is recommended to consider NGMN recommendations on standardized O&M also for Core Network Management.

4.10.3.2 Recommendations for implementation

Areas as described in chapter 7.2.1 are also in focus for implementation in the area of SON.

Here a not complete list of example functionality which could improve operational efficiency also in CN:

- Support of Plug'n Play eNB deployment and X2 configuration
- Support of CN node installation in a plug'n play approach
- Ability to load balance across a pool of MMEs
- Ability to load balance across a pool of S-GWs
- Tracking Area Optimization: Find trade-off between paging signalling load and load due to tracking area updates
- Statistical monitoring tools to detect and support analysis of network problems
- Expert wizards supporting operator to identify problems and recommend countermeasures
- Automatic SW Management
- Configuration Management tools to ensure efficient configuration
- Data and Network parameter Inventory
- Optimize transport parameter with minimal operational effort
- Optimization of data routing in a meshed network

For further details please refer to [15].

4.11 QoS Optimization

4.11.1 Abstract

One major target of a mobile network provider is to deliver a good quality to customer respective experiencing throughput and delay. Basic radio resource mechanisms like admission control, bearer handling, handover procedure have all the target to achieve a good customer experience. The voice bearer in GSM was the very first guaranteed bearer to meet this quality target. Additionally specific QoS mechanism are developed during evolution of mobile networks like definition of a maximum bit rate for best effort bearers, guaranteed bit rate bearer for data sessions or prioritisation of bearer. We see today the situation that the QoS implementation and the usage of QoS in real networks as being very inhomogeneous. Several concepts could be used like user prioritisation (famous gold, silver, bronce user definition) or service prioritisation via guaranteed bit rate bearer or packet/bearer prioritisation. On the other side often seen approach is to over dimensioning resources with the results that dedicated QoS mechanism are not or not in full extension used.

Nevertheless with more and more economic pressure on mobile market and in parallel massively growing mobile traffic it is assumed that QoS mechanism can help to use scare resources more efficiently.

From a SON point of view the mentioned QoS mechanism have already a strong "SON character" because they handle the resources based on defined rules in a automatic way targeting a optimum of quality.
But in this chapter the focus is on Optimization of QoS related parameter which is described more in detail in the following. It can be seen as a fact that for QoS and in general quality monitoring and Optimization today analysis of performance measurements are used and drive tests which gives the basis for finding default values and optimised parameter related to QoS.

4.11.2 Expectation of benefit - saving potential

The efforts of this often manual tasks of experts - as described in the previous chapter - shall be minimised to focus expert knowledge more on exceptional trouble cases.

4.11.3 Recommendations

Following recommendations are seen on QOS Optimization:

- QoS related PM shall be supported (as listed in chapter 6.3???)
- In general QoS optimization features are expected as discussed in this documents. It is believed that specific LTE experiences are needed to decide on highlighting specific use cases for QoS optimization. Vendors are asked to design and implement their algorithm and functionality related to QoS in a way that parameter optimization is not minimized from operator's point of view – also with support of SON features bringing such optimization activities on lower network levels to relief operator from optimization work. Solutions shall consider the generic recommendations on SON support as given in chapter 4.1.3.

4.11.4 Proposal to the standards:

In an E-UTRAN cell the quality of service achieved is directly influenced by a number of factors, including:

- Loading of users on the cell
- Traffic loading and characteristics
- UE locations and mobility
- RRM policies
    - Scheduling
    - congestion control
    - admission control
    - layer 2 protocol configuration
- Mapping of traffic to QCI
- Setting of QoS parameters other than the QCI.

It is very important to be able to monitor the QoS to determine whether the combined effect of these policies, algorithms and external factors is satisfactory. Unsatisfactory QoS may rectified by adjusting policies and RRM settings, for instance.

It shall be ensured that an essential set of PM is given in standards as e.g.:

#	PM
1- 1	Number of successful sessions per QCI
1- 2	Number of dropped sessions per QCI
1- 3	Cell specific Customer Satisfaction Rate
1- 4	Min/Avg/Max Throughput per QCI
1- 5	Min/Avg/Max Round Trip Delay per QCI
1- 6	Packet Loss per QCI
1- 7	Mean number of RRC connected users
1- 8	Mean number of RRC connected UEs with data to send per QCI
1- 9	Percentage of UEs per cell that is NOT achieving their required GBR and NOT achieving the required SDU Error Ratio per QCI
1- 10	Percentage of UEs for which transfer delay per IP packet was above a particular threshold
1- 11	Percentage of UEs for which average throughput measured at RLC layer for each non-RT QCI was below a particular threshold
1- 12	Percentage of UEs per QCI for which the SDU Error Ratio is above a certain level
1- 13	Number of RRC Connected UEs with measurement gaps configured.

For further details please refer to [14].

5. PERFORMANCE MANAGEMENT ENHANCEMENTS

5.1 Abstract

Major challenge of Performance Management is providing the relevant counters as fast as possible and in a maximum efficient way. Therefore, future Performance Management capabilities have to consider the recommendations for *online performance management* as well as the need for *optimized configuration*, *administration* and *monitoring* of performance data with respect to the available technical and human resources.

Dedicated reports of specified KPIs for trouble shooting purposes support *automatic identification of network problems and automatic error correction proposals.*

5.2 Expectation of benefit - saving potential

- Earlier availability and visibility of performance data leads to faster error detection and correction. This reduces the *time back-to-service*.
- Efficiency gain for measurement configuration, administration and monitoring tasks

5.3 Recommendations

- Free configurable measurement and delivery periods for each counter or counter group.
- Efficient data transfer mechanism, e.g. simply structured and compact raw data format with a maximum net data rate, e.g. csv (current XML-based 3GPP standard has large overhead; might be improved using e.g. appropriate compression methods; subject for standardization)
- EMS internal post-processing of raw data without significant delay (near real-time)
- Automated counter or counter group administration (incl. activation).
- Automated performance data quality management, e.g. automatic counter restart after outage
- Function for simple threshold based on counters and KPIs
- Function for simple KPI calculation based on counters
- Automatic identification of network problems and error correction.
- Standardisation of PM is key to support seamless PM integration in multi vendor scenarios
- There is a clear tendency to enable real time behaviour of PM delivery to understand more quickly situation in the network
- UE-based measurement (as for MDT) are seen as part of significant information covered by the topic PM.

Please refer on [2],[3],[5] and [6].

6. ENHANCEMENT OF TRACE FUNCTIONALITY

6.1 Abstract

In comparison with active service testing (e.g. through "robots") passive monitoring via probes means the permanent monitoring, storing and processing of relevant signaling network data. These data contain control plane as well as user plane data.

Today current vendor call and IMSI trace solutions are often only limited to single network elements. Probing capabilities across several network elements and technologies are not supported.

6.2 Expectation of benefit - saving potential

Centralized management for monitoring and collection of network measurements and events reduces the operational effort

6.3 Recommendations

- The infrastructure system supports trace functionality as specified in 3GPPP 32.421, 32.422, and 32.423. It shall be possible to trace information (standardized or proprietary) on interfaces Uu, S1, X2.
- The trace functionality is seen as basis for trouble-shooting, optimization, network wide monitoring and trouble detection and customer specific trouble shooting.
- Tracing shall rely on UE support for transparent collection and reporting of measurements / events
- Interface to external 3rd party systems like Customer Experience Mgmt systems
- User Call Trace applications should be able to capture and store real-time data for specific calls or subscribers across several network elements and technologies (e.g. 2G/3G/LTE).
- Tracing and logging of all successful and unsuccessful calls to any of registered numbers
- Enhanced functions shall efficiently support the tracing for a high number of users / events with limited impact on the existing network infrastructure.
- Application has to offer the ability to set call identifying parameter values. These settings shall act as call / transaction filters. Each parameter of every protocol has to be available for selection.

  Typical filter parameters should be:
    - Called party number, calling party number
    - MSISDN, IMSI, IMEI
    - Service of call (Speech, Video telephony, SMS, Supply. Services)
    - Location Area Code, Cell ID
    - Access Point Name
    - Service Area Code
    - GSN-IP addresses, MS-IP addresses, HSDPA, HSUPA usage

7. ENODEB PLUG & PLAY - SELF COMMISSIONING

7.1 Abstract

Automated network integration of new eNodeBs via auto connection to OSS (DHCP, Network Element Manager), core network (S1), Security Gateway and neighbor sites (X2). The auto configuration functionality deploys the required data (e.g. SW, firmware, parameters, etc.) automatically.

7.2 Expectation of benefit - saving potential

Potentially reduce the number of on-site visits to just one. Manual configuration effort of Radio, Core and Transmission Network can be significantly reduced.

Prerequisites have to be fulfilled like automated IP Sec Certificate and License Management. In addition the IP network has to be configured in advance (e.g. IP routing).

7.3 Recommendations

Automatic Self Configuration of eNodeB shall be fully supported. OSS shall support plug and play of eNodeB including automatic setup of secure X2 & S1-u / S1-MME configuration as below:

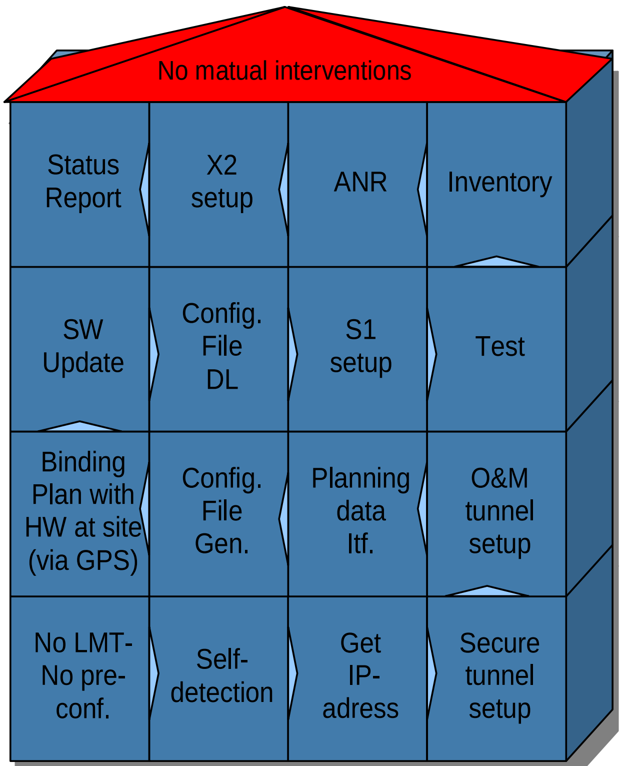


Figure 1: High level overview about the steps in a plug'n play process after planning

- Automated equipment, radio network and transport network data planning and preparation should be supported
- The number of to be planned parameters shall be minimized e.g. by automatic SON functionality as Automatic Neighbour Relation (ANR).

- The following procedural steps assume that no medium at the site is needed for eNodeB specific configuration as e.g. a local maintenance terminal.
- Self-detection of equipment and appropriate self-configuration related to this equipment should be supported
- Auto connection to the network should be supported leading to a setup of a secure tunnel
- Auto configuration of SW and planned and default configuration data during self configuration should be supported
- Automated deployment of licenses during self configuration should be supported: License management should be transparent for the operator and must not cause any negative deployment and deployment impact
- Automated integration into the access-, core- and network management network should be supported (automatic setup of secure X2, S1-u / S1-MME & OAM channel)
- Auto Connection with the Authentication Node via Operator's Certificate repository should be supported.
- Automatic self test and cell/common channel setup should be supported.
- By auto inventory all changes are available. Following the final self test the eNodeB delivers
  - a state change notification
  - details on its HW resource configuration (HW resource inventory)
  - details on its parameter configuration (configuration inventory) as e.g. complete configuration set, SW version etc.
- Depend on operator's policy, the new eNodeB is put into reserved mode for operator use (e.g. operator tests, from special UEs) or on air immediately.
- Radio neighbours are automatically detected and configured by 3GPP ANR functionality. Automatic X2 setup is done considering security recommendations.
- Site intervention for configuration shall be minimized. Site intervention should be limited to basic H/W node and necessary transmission H/W installation. Manual capture of node data on site (e.g. H/W serial number) shall be avoided. A process of one time site visit for eNodeB service activation shall be provided.

In 3GPP SA5 work Item "Self-Establishment of eNodeBs", the recommendations and implementation method of automated eNodeB bring up function was studied and the result are written in TS 32.50x series specifications. Besides Self-Establishment of eNodeB, Automatic Radio Network Configuration Data Preparation , Automatic radio automatic Neighbour Relation (ANR) management, standard Software management and standard Authentication/Certificate functions are also required by Plug n' Play eNodeB.

For further details see [4].

8. OSS STANDARD ITF-N

8.1 Abstract

Although it is not the intention of the current document to specify implementation details, the operators expect the industry to jointly develop and use common standards, which deliver the semantic connectivity and not only the underlying transport mechanisms. The goal is to achieve out-of-the-box interoperability and more flexible integration, as well as the re-use of the same interfaces between OSS/BSS and the Network or EMS. Based on existing frameworks, provided by the standardization bodies, solutions should be implemented that support plug & play behavior of network and OSS/BSS infrastructure. This will lead to more open interfaces to allow for 3rd party software integration.

Amongst others this implies usage of common data models, e.g. based on SID, interface standards, such as SNMP and XML (if appropriate), and state-of-the-art technologies as SOA, web services, etc. As those standards are evolving over time, the operators resign from specifying exact software versions and implementation details. Our aim is to ensure upwards and downwards compatibility to ease integration of multi-vendor, multi-technology systems for all management areas.

8.2 Expectation of benefit - saving potential

The support for a better level of standardization of the itf-N will reduce the integration effort between EMS and NMS (OSS) during the implementation and the life cycle of network technologies and related EMS.

Possible issues for guidance:

- "Plug & Play" integration of EMS into the OSS environment (no additional cost and effort during the implementation and the life cycle of network technologies and related EMS)
- De-coupling of EMS – OSS layers (changes on EMS or on NE may not lead to changes on OSS layer)
- Re-use of OSS client interfaces

8.3 Recommendations

This chapter contains "generic" recommendations only, valid for each type of interface between EMS and NMS.

- **"Plug & Play"** → It must be possible to implement the interfaces between network and OSS systems easy and efficient by lowest costs and smallest effort (ideally without any development and/or configuration).
- **Useful** → It must deliver efficient support for the OSS business processes. The interface must deliver the needed OSS semantics to support the process.
- **Re-useable / Generic** → The interface must be generic enough, to enable the re-use in different integration/business scenarios
- **Flexible / Extensible** → It must be possible to extend the interface capabilities (methods and attributes), without breaking the standard
- **Standardized / Open** → The interface has to be based on unambiguously standardized specification, which does not allow room for interpretation. The specification and related artefacts must be freely available and useable for everybody.
- **Mature / Stable** → The interface must be stable and mature, to avoid expensive changes on implemented interfaces.
- **De-coupled** → Changes in the application or in the interface implementation at one of the communication partners may not lead to the need for changes in the application or in the interface implementation of the other communication partners.
- **Evolutionary** → OSS interface shall re-use already existing, widely adopted and mature IT standards (e.g. transport protocols) to avoid "reinventing the wheel".
- **Independent** → The interface specification must be independent from underlying infrastructure.

- **Upward / Downward Compatible** → It must be possible to implement a new version of an interface specification at one of the communication partners, while the other communication partners still use an old version of the interface specification.
- **Interoperable** → The interface implementation shall be based on an interoperable portfolio of interfaces / interface specifications to support different OSS business processes using a common architecture and a common information model.
- **Scalable** → No performance constraints caused by the interface specification or the implementation.
- **Secure** → The interface has to be able to ensure confidentiality and availability of the data, which is transferred by the interface.
- **Reliable / Having Integrity** → The interface implementation has to ensure the reliability and the integrity of the data, which is transferred by the interface.
- **Adopted & Verified** → Widely adopted and verified, so that every vendor supports it.

8.3.1 IRP Ensembles

The need for MNOs was identified to have a tool enabling them to understand precisely what a given Itf-N interface should be made up of, i.e. instead of the whole bunch of 3GPP IRPs (Integration Reference Points), it appears that only some subset is required for a given Network Management Application Profile. A list of most relevant profiles has been identified by MNOs, providing some first elements about which IRPs should be part of the corresponding IRP Ensembles.

Further details are presented in [3].

Further investigation is needed on the following aspects:

- Should IRP Ensembles be normative or informative?
- Which formalism would be the most appropriate to specify IRP Ensembles?

These questions shall be addressed in standardisation bodies and should be in focus of following operator initiatives.

8.3.2 SON/O&M Implementation Conformance Statement

Some need has been identified for MNOs to have a tool enabling them to check how conformant vendors' implementations are with respect to 3GPP OA&M / SON IRPs. By "Implementations", we mean here either EMS systems, NMS systems or NPOT applications. A 3-staged top-down conformance checking methodology is introduced as well as an example of SICS (SON/OA&M Implementation Conformance Statement) proforma. The benefit of such tools for MNOs is to be able to evaluate how high the cost for integrating the implementation in their OSS would be, in terms of CAPEX, OPEX and Time-To-Market.

Further details are presented in [2].

8.3.3 NGOSS/SOA

The convergence of access and core network technologies towards a common IP-based approach will bring many cost saving options. Tomorrow the biggest value of NGN will be to enable the rapid & flexible delivery of new services, through IP transport network, from service delivery platforms to the end user device.

Therefore following recommendations are given to enable an NGOSS and SOA compatible network system:

- Network Operators should support the standardization of end-to-end seamless integrated management system for Network and Service Delivery Platforms;
- This should be based on a service-oriented (SOA) aggregation layer as a "blueprint architecture";
- This should reuse the fully re-usable and widely deployed 3GPP IRP Framework to manage Wireline Network with possible extensions due to the ongoing alignment process between 3GPP generic NRM and TM Forum SID framework;

- Most network elements, IS & service delivery platforms should support a multi-vendor XML-based Web Services standardized interface;
- It is recommended that Mobile Network Operators drive the harmonisation of TM Forum Interface Program (TIP) and 3GPP Integration Reference Points (IRP).

Further details are presented in [4].

9. OSS TOOL SUPPORT FOR OPTIMIZATION & OPERATION

9.1 Abstract

Tools and application in the north from the OMC plays a significant role in an operator organization to coordinate operator processes: e.g. workflow management tools, optimization tools and data bases. In this chapter the focus is on recommendations regarding these tools as complementary area of the chapter OSS Standard Interface covering the standard northbound interface which is the bridge between the so called OSS tools in the north and the radio and core network infrastructure network element mangers (or OMC).
The main idea of this section is to formulate main use cases and recommendations on related tools in OSS to support standardization.

9.2 Expectation of benefit - saving potential

The potential savings and benefits of standardized interfaces and main definitions of use cases and related recommendations on OSS tools is seen in form of reducing integration costs of such OSS tools and followed by standardization by improved and better tailored products,

9.3 Recommendations

The recommendations on Optimization in NMS layer can be described as in the following. Generally the recommendations as given in chapter 4.1.3 (Recommendations on OSS support for SON) are applicable and repeated to underline their importance for OSS tool support.

- SON Functionality /Capability shall have controlled implementation in order to build trust and confidence in automation and avoid massive operational impact
- SON solutions shall provide an easy transition from operator controlled (open loop) to autonomous (closed loop) operation, as the network operator gains more trust in the reliability of the SON.
- For operator controlled (open loop) SON function, the implementation of any update proposed by the SON function shall take effect only after a response by the operator. OSS should provide the possibility to configure certain break points for SON operations, allowing the operator for manual intervention to proceed with the logic, or to halt / abort it. The vendor shall provide a prediction of the expected results prior to executing SON logic. The operator shall be able to proceed with the logic after having previewed the expected results.
- For closed loop SON function, the implementation of any update proposed by the SON function shall take effect without the need for response by the Operator.
- An NE can operate with SON function or without SON function and can easily be transferred between these two modes. The ability to suspend/ resume/ enable/ disable the SON function shall be determined on a case by case basis.
- The IRPManager shall be able to monitor the specific results of each particular SON function OSS should provide a general SON Monitoring & control Application covering policy control, History log and switch on/off functionality. OSS shall be synchronized in real time with SON initiated network changes.

- During open loop operation, Network Operations Staff manually reviews the results of the SON function at intermediate steps in the particular SON process. The network operations staff decide upon and manually initiate the appropriate next step in the SON process.
- The vendor shall provide for each SON feature a methodology to demonstrate the robustness & quality of the SON feature related algorithms (e.g. through simulations under various conditions).
- The vendor shall provide for each SON feature a methodology for acceptance of the feature.
- Network and Management System should provide a general SON Monitoring & control Application covering policy control, History log and switch on/off functionality per site and cell.
- If SON is not functioning as expected, it shall be possible disable individual portions and perform the operation manually.
- SON centralized, distributed and hybrid approach must be supported (depending on the SON Use Case)
- Network and Management System should provide possibility to configure certain break points for SON Operations , allowing the operator for manual intervention to proceed with the logic, or to halt / abort it.
- Network and Management System shall be synchronised in real time with SON initiated network changes. Notifications shall also be available real-time via the CM Northbound Interfaces to NMS.
- Network and Management System should provide a valuable Reporting Suite for SON activities.
- Network and Management System shall fully support SON as defined in 3GPP Standards, inclusive CM Northbound Interface 3GPP BulkCM IRP (CORBA or SOAP based)
- Provide an open Northbound Interface for all SON related Parameters for Interoperability with 3rd party vendors.
- Network and Management System should be able to request or report the SON related changes for statistical analysis and historical view
- It shall be possible to customise SON policies. On the one hand, there shall be flexibility to adjust the SON functionality to the operator's recommendations. On the other hand, customisation shall be a simple process to minimise the manual effort required.
  - Optimization for identified parameters can be done within a value range, defined by the operator. (see also note in chapter 4.2.3)
  - Optimization shall be done with respect to KPIs and parameters not directly related to the use-case KPI (i.e. other KPIs shall not become worser than defined thresholds (e.g. Handover-Optimization shall be done with respect to capacity related parameters resp. KPIs).
  - Dependency between KPIs resp. definition which KPIs shall be considered in addition to use-case KPI(s) shall be configurable by the operator.
  - Thresholds for start and end point of parameter Optimization shall be configurable by the operator.
  - Optimization cycle should be configurable (periodically, event-based)
- Support of centralized, distributed and hybrid solution
  - Degree of automation configurable by the operator.
  - Optimization cycle completely automated: yes / no
  - Automated import of optimized settings: yes / no

From the above recommendations, the Open and Close Loop architecture should support the following functionalities. It is highlighted that these recommendations for the following functionalities are addressed to all relevant standardisation bodies and bodies influencing standardisation and industry practices (3GPP Working groups such as e.g. SA5 or TM Forum or others). It is the task of these bodies to decide and to agree on work split and definite body specific areas.

1. ANR
    - EMS shall fully support ANR as defined in 3GPP Standards, inclusive CM Northbound Interface 3GPP BulkCM IRP (CORBA based). ANR based changes in the eNB shall be "online" synchronised with EMS.
    - The ANR functionality supports a real time behaviour of relationship configuration to ensure that HO is possible a few seconds after neighbour detection.
    - OSS to be able to configure / manage "no X2 flag", "no remove flag" and "no HO flag" (as opposed to eNB only per 3GPP) .
    - OSS to support monitoring of the main ANR steps:

- Neighbor cell detection
- X2 Set-up
- Neighbor cell configuration adaptation
- ANR Optimization

2. Cell Phy_ID allocation & configuration shall be automated;
    - OSS should provide analysis, alarms and user friendly visualization for Phy_Cell_ID collision and confusion detection
    - OSS should provide the operator with resolution scenarios as suggestions for Phy_Cell_ID collision and confusion, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
3. Cell Outage Detection and Compensation
    - OSS should provide analysis, alarms and user friendly visualization for cell/service outage detection.
    - OSS should provide the operator with resolution scenarios as suggestions for specific cell/service outage situation, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
4. Load Balancing
    - OSS should provide analysis, alarms and user friendly visualization of load situations in different RATs.
    - OSS should provide the operator with resolution scenarios as suggestions for overload situations, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
5. HO (Mobility) Optimization
    - OSS should provide analysis, alarms and user friendly visualization of HO related statistics as HO failure rate per neighbour combination or call drop rates etc.
    - OSS should provide the operator with resolution scenarios as suggestions for HO mobility related problem, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
6. Trace Management for Optimization Purpose
    - OSS should provide analysis, alarms and user friendly visualization for general Optimization purpose as available based on trace data. It is possible to correlate trace data with other information as PM, alarms etc.
    - OSS should provide the operator with resolution scenarios as suggestions for problem scenarios identified by trace data and other correlated data, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
7. QoS Optimization
    - OSS should provide analysis, alarms and user friendly visualization for QoS related problems as low threshold per user, higher delays or blocking rates.
    - OSS should provide the operator with resolution scenarios as suggestions for QoS problems, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
8. Tracking Area Optimization
    - OSS should provide analysis, alarms and user friendly visualization for tracking area related issues as high paging load or high tracking area update load in a certain cluster.
    - OSS should provide the operator with resolution scenarios as suggestions for specific TA area problem scenarios, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
9. SON in Core net
    - Strong focus is on use cases in the RAN area to define Optimization use cases and their SON solutions. It is highlighted that also in CN interesting use cases can be beneficially be covered by SON functionality as e.g. load balancing among core network nodes (MME, S-GW).

10. Energy Saving
   - OSS should provide analysis, alarms and user friendly visualization to understand the energy consumption within a network.
   - OSS should provide the operator with resolution scenarios as suggestions for finding scenarios with minimised energy consumption in a cluster, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
11. Common channel Optimization
   - OSS should provide analysis, alarms and user friendly visualization related to common channel Optimization as e.g. the load on common channels or specific errors.
   - OSS should provide the operator with resolution scenarios as suggestions for solving common channel related problems, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.
12. Optimization reg. Interactions between Macro and Home eNB
   - OSS should provide analysis, alarms and user friendly visualization related to Home and Macro eNB interworking scenarios as e.g. interference situation in Macro and Home eNB layer.
   - OSS should provide the operator with resolution scenarios as suggestions to solve negative impact of one layer onto the other one, which the operator can choose and select to solve the conflict resolution. Optionally these suggestions can be enabled automatically following operator policies.

In the following also operation related use cases should be mentioned to be handled by OSS functionality:

13. Automatic Inventory
   - OSS supports the automatic inventory by an configuration management system based on standardised and proprietary infrastructure input.
   - Vendor infrastructure (RAN & Core elements)
   - Standardised interface for signalling information about changes performed in the Network.
   - Standardised interface to poll the information about Network Element Configuration and Components.
   - All changes are available via a push or pull mechanism. E.g. Following the final self test the eNodeB delivers
     - a state change notification
     - details on its resource configuration (resource inventory)
     - details on its parameter configuration (config. Inventory)
     - The pictures on the next page is meant to illustrate the High Level architecture of CMS integration in Operators OSS environment
   - There should be a standardized network (resource) inventory model which will enable to create centralized cross-domain multi-vendor Inventory which can be filled with data provided by domain specific NEMs. Standard model is expected to eliminate costs for translating vendor specific network resource models.
   - It should be possible to leverage TM Forum SID model as e.g.:
     - Describe radio lines
     - Describe dependency between logical connections and physical layer.
   - It should be possible to reuse 3GPP Inventory functionality defined in TS 32.69x series.
   - The standardized network inventory should be extendable, for example
     - For FM – there should be a dictionary of common problems referring to the appropriate types of resources. This dictionary should by used by NEMs when reporting alarms to indicate the type of problem

- For Performance Management – there should be a set of KPIs defined per resource to which the standardized KPIs refer to. This would enable to create standardized dictionary of KPIs

- NEM should assure consistency between inventory data which it provides up to central Inventory and data exposed by other functional interfaces, for example on FM interface or Performance Management Interface .

14. Information correlation for fault management and automated fault correction
    - NEM should provide standard itf-N interface for delivering FM functionality. The interface should provide information about alarms according to the standard format.
    - To assure semantic consistency between NEMs provided by different vendors, FM interface should leverage a standard reference resource model. This is a necessity to assure that incoming alarms can be correctly interpreted by identifying resource type (NE type) an alarm refers to. This is even more important for inter-NEM correlation. Standard reference resource model should include topology relations and dependency between NEs and thus enable proper interpretation of alarms.
    - One of the essential responsibilities of NEM should be unique identification of NE (Managed Object) to which the Alarm (Event) refers. The aim is to enable precise identification of the MO in the OSS_NetworkInventory and thus to enable correlation of multi-vendor alarms.
    - NEM or deeper level should perform initial root cause analysis and correlation in order to be able to provide the most precise information about a fault as it is possible to infer within the NEMs domain.
    - The correlation of alarms done by a NEM should be described in the standard way leveraging the standardized network model. For example the alarm informing about radio line failure, when indicating that the root cause is a transceiver problem, should leverage a standard model for describing a radio line and its transceivers.
    - The cause of a fault identified by a NEM should be contained in an Alarm in standardized manner to avoid the need for vendor specific alarm processing.
    - There should be standardized dictionary of problems, causes of failure defined together with the network model. This recommendation is meant to avoid vendors using their own vendor specific codes to inform about the common problems.
    - There should be a standardized interface between OSS_NetworkInventory and OSS_ServiceInventory which would enable to identify services implemented over the resources and thus enabling to calculate the service impact of a resource fault.
    - There recommended interface between OSS_NetworkInventory and OSS_ServiceInventory should be based on SID model taking as a skeleton for integration the "Customer Facing Service-Resource Facing Service-Resource" model to glue network resource domain with the service one.
    - There should be a standard interface between OSS_FaultManagement and OSS_CellOutageCompensation enabling OSS_FaultManagement to initiate Cell Outage Compensation process.
15. Real time Performance Management

    - Free configurable measurement and delivery periods for each counter or counter group.
    - Simply structured and compact raw data format with a maximum net data rate, e.g. **csv** (current XML-based 3GPP standard has large overhead)
    - NEM Internal post-processing of raw data without significant delay (near real-time)
    - Automated counter or counter group administration (incl. activation).
    - Automated quality management of performance data, e.g. automatic counter restart after outage
    - Function for simple threshold based on counters and KPIs
    - Function for simple KPI calculation based on counters
    - Automatic identification of network problems and error correction.

16. SW Management:

    - **"NE health-check"**: OSS system has to be able to verify automatically that network elements are ready for software upgrade. The health-check (e.g. faulty HW Modules, critical alarms, free disk space) has to be executed during the dayshift to ensure the correct behaviour and preconditions of the NE itself.
    - **Automated Software download:** The Software download to the NE's should work in parallel with a minimum of unavoidable manual steps. A result overview list must be provided.

- **One-click NE Software activation:** Software activation should also work in parallel with a minimum of unavoidable manual steps. The NE health-check should support also the wrap-up activities for urgent issues.
- **Automatic rollback:** Only if the software activations fail completely an automatic rollback should be initiated.
- **Long Term Vision:**
    - SW package is made available on OSS and NEs are tagged on OMC for upgrade. Policies for software activation are set.
    - All necessary activities (NE-health check, SW-download, SW-activation, corrective actions) are carried out policy controlled by the software management application.
    - A final upgrade report is provided that will be used as basis for the final wrap up phase.
    - It is understood that with the long term approach the operator looses detailed control of each single step necessary for a software upgrade. A policy controlled bulk software upgrade is expected to be less error prone than today's solutions

Please refer also to [6].

10. AUTOMATIC INVENTORY

10.1 Abstract

An Automatic Inventory function shall synchronize in real time with the Configuration Management system (CMS). Notification of any change to a passive or active element or its configuration relevant to a business process must be possible, consumer of that might be directly the Configuration Management System (CMS) / Network Inventory or other OSS Systems. The same information shall also be available in addition via batch load or polling mechanisms.
The Configuration Management System (CMS) is the grouping of all relevant inventory systems to provide information required by the Planning, Deployment and Operations Processes.

10.2 Expectation of benefit - saving potential

The introduction of standardized functions and protocols to support Automatic Inventory will ensure:

- more efficient management of configuration data in the CMS
- availability of accurate and real-time information, as a basis for Planning, Deployment and Operation

10.3 Recommendations

Vendor infrastructure (RAN & Core Network elements)

- Standardized interface for signalling information about changes performed in the network.
- Standardized interface to poll the information about Network Element configuration and components.
- All changes are available via a push or pull mechanism.

E.g. following the final self test the eNodeB delivers

- a state change notification
- details on its resource configuration (resource inventory)
- details on its parameter configuration (configuration inventory)

Please refer also to [2], [3], [4] and [5].

ABBREVIATIONS

ANR Automatic Neighbour Relationship
3GPP 3rd Generation Partnership Program
BSS Business Support Systems
EMS Element Management System (a.k.a. NEM)
IMS IP Multimedia Subsystem
IRP Integration Reference Point
IS Information System
Itf-N Interface North
NE Network Element
NEM Network Element Manager (a.k.a. EMS)
NGN Next Generation Network
NMS Network Management System
OAM Operation and Maintenance
O&M Operation & Maintenance
OSS Operational Support Systems
OPE Operational Efficiency
SA5 Working group in 3GPP on OA&M
SLA Service Level Agreement
SOA Service Oriented Architecture
SOAP Simple Object Access Protocol
TCO Total Cost of Ownership
TM Forum Tele Management Forum
WSDL Web Service Definition Language
XML Extensible Markup Language

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