Recommended Practices for Multi-vendor SON Deployment

Deliverable D2

by NGMN Alliance

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Deliverable D2
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1 INTRODUCTION

1.1 Revision History

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1.2 References


[6] 3GPP TS 32.522 V11.5.1 Technical Specification Group Services and System Aspects; Telecommunication management; Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS), (Release 11)

[7] 3GPP TS 36.423 V11.3.0, X2 application protocol (X2AP); (Release 11)

[12] 3GPP TS 32.101 V11.1.0 Technical Specification Group Services and System Aspects; Telecommunication management; Principles and high level requirements (Release 11)
[13] 3GPP TS 32.541 V11.0.0 Technical Specification Group Services and System Aspects; Telecommunication management; Self-Organizing Networks (SON); Self-healing concepts and requirements (Release 11)
[14] 3GPP TS 32.551 V11.3.1 Technical Specification Group Services and System Aspects; Telecommunication management; Energy Saving Management (ESM); Concepts and requirements (Release 11)
[16] 3GPP TS 32.103 V11.3.0 Technical Specification Group Services and System Aspects; Telecommunication management; Integration Reference Point (IRP) overview and usage guide (Release 11)

1.3 Abbreviations, Definitions and Terminology

1.3.1 Abbreviations

<table>
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<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>3GPP</td>
<td>The 3rd Generation Partnership Project</td>
</tr>
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<td>ANR</td>
<td>Automatic Neighbour Relation</td>
</tr>
<tr>
<td>CCO</td>
<td>Coverage and Capacity Optimisation</td>
</tr>
<tr>
<td>CIO</td>
<td>Cell Individual Offset</td>
</tr>
<tr>
<td>EARFCN</td>
<td>eUTRA Absolute Radio Frequency Channel Number</td>
</tr>
<tr>
<td>ECGI</td>
<td>eUTRAN Cell Global Identifier</td>
</tr>
<tr>
<td>eNB</td>
<td>Enhanced Node B</td>
</tr>
<tr>
<td>EMS</td>
<td>Element Management Sub-system</td>
</tr>
<tr>
<td>HetNet</td>
<td>Heterogeneous Network</td>
</tr>
<tr>
<td>HOF</td>
<td>Handover Failure</td>
</tr>
<tr>
<td>IOC</td>
<td>Information Object Class</td>
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<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
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<tr>
<td>MLB</td>
<td>Mobility Load Balancing</td>
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<tr>
<td>MME</td>
<td>Mobility Management Entity</td>
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<tr>
<td>MRO</td>
<td>Mobility Robustness Optimisation</td>
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</tbody>
</table>
1.3.2 Terminology

**CIO and Ocn**: Ocn is the cell specific offset of the neighbour cell (i.e. cellIndividualOffset IE as defined within measObjectEUTRA, TS36.331 [19]).

**Offline Agreements**: In this document the offline agreements refer to agreements made between operators and their vendors to enable multi-vendor interoperability in a specific network; usually by alignment of systems behaviour (e.g. specific parameter setting – such as cause values, specific algorithmic behaviours, specific signalling sequence etc.) that otherwise would not be directly addressed by 3GPP standards as part of implementation.

1.4 Purpose and Scope

This document is the NGMN P-SmallCell Work Stream 2 (WS2) first deliverable. The main objective of WS2 is to promote multi-vendor deployment in HetNets, with a focus on SON interoperability.

This first deliverable covers the following topics:

- General multi-vendor interoperability assumptions and targets
- Perimeter of the study
- Performance metrics definition and performance targets in multi-vendor configurations
- Reference SON architectures and interfaces and some implementation options
- SON features description and analysis of multi-vendor deployments
- Descriptions of potential interoperability issues for each SON feature and the recommended proposals for solving or reducing these issues.

A set of recommendations aiming at solving interoperability issues is developed. For example, recommendations may consist of specific interpretation or usage of IEs over X2. Such recommendations are primarily addressed to vendors, but can in some cases also apply to standardization bodies. The adoption of the implementation guide is voluntary.

This document is envisaged to be an input into the second WS2 deliverable, ‘Multi-vendor Deployment Enablement Test Development’, which will include test development, interoperability performance verification and execution.

The general approach adopted for this analysis is to consider a variety of vendors’ implementations.

The WS2 deliverables protect vendors’ know-how by considering vendor eNB and NM proprietary algorithms as a black box. When algorithms from different vendors need to interact – a situation arising for distributed algorithm interacting through X2 – tests shall be done without requiring the knowledge of the other party.
algorithm. In specific cases, and on a voluntary basis, algorithm details may be disclosed to the other party if this is useful.

In order to enable an in-depth analysis, the scope of the present study is limited to the following:

- LTE only (excluding 2G and 3G)
- SON analysis limited to the interactions between the small cell and macro layers in HetNets.
  Note: It is possible that some parts of the analysis are also applicable to macro-macro interactions as well as HeNB, but they have not been analysed in this document
- HeNB are excluded from the analysis
- Only the following set of SON features is analysed
  - PCI Optimization,
  - ANR,
  - MRO,
  - MLB,
  - CCO

The document's baseline assumption is to consider the versions of these features as specified by the 3GPP up to Release 9. Improvements introduced in subsequent releases are excluded from the scope.

The scope may be extended to other areas such as multi-RAT or additional SON features in a subsequent phase.

2 SON FEATURES

This section provides high level description of the SON features covered in the document. More detailed descriptions can be found in [3] and [8], for example.

Most of the SON features have been introduced in 3GPP releases R8 and R9 as indicated below:

Release 8:
- Automatic Neighbour relation (ANR)
- eNB and MME self configuration
- PCI optimization

Release 9:
- Mobility Load Balancing
- Mobility Robustness optimization

Improvements and extensions of these functions as well as additional functions are introduced in R10 and R11 of the 3GPP. Details can be found in [9].

2.1 PCI Optimization

The physical cell identity (PCI) is used as a regionally unique identifier of a cell at the physical layer. The purpose of PCI Optimisation is to detect and resolve PCI conflicts. PCI conflict is either a PCI collision (PCI is
not unique in the area that the cell covers) or a PCI confusion (a cell has neighbours with identical PCI). PCI collision/confusion can only occur between cells assigned with the same EARFCN.

There are 504 assignable PCI values in total, which inevitably leads to re-use of PCIs.

PCI conflicts can be detected over X2 or by ANR measurements (CGI reporting). The PCIs of an eNB’s served cells and their neighbour cells can be exchanged during the X2 Setup and eNB Configuration Update procedures.

Figure 2-1 below shows the messages involved in the function on X2 and Itf-N.

In case of collision or confusion, PCI Optimisation resolves the conflict by re-assigning PCIs. Reassignment of PCIs may cause a service disruption and therefore unnecessary reassignment should be avoided.

The operator, via O&M, can let each eNB choose its PCIs autonomously, or alternatively, assign ranges of possible PCI values to accelerate the algorithm convergence, or even impose PCI values to each eNB.

When eNB chooses the PCIs autonomously, allocations and updates are reported back to NM. NM also gets reports of collision/conflicts from eNB. Planning tools combined with collision/conflicts reports (as well as other kinds of reports) can be the inputs of a centralised PCI optimization function.

### 2.2 Automatic Neighbour Relation

The purpose of the ANR is to build the neighbour relation table.
The feature can be implemented in a centralised or distributed way. The general modes of operation are illustrated in Figure 2-2.

In distributed implementation, eNBs build their NRTs using measurements from the UE they serve. UEs report the PCI (Physical Cell Identity) of the cells that they have detected to their serving eNB. When the eNB does not recognize the PCIs, it may require the UE to provide additional information, such as the ECGI (E-UTRAN Cell Global Identifier), as well as other complementary information related to the cell detected.

This information is used by the eNB to build and update its NRT (Neighbour Relation Table).

In addition to the neighbour cell identity (PCI, ECGI, TAC and PLMN Id) the table includes the following attributes for each NR (Neighbour Relation), primarily used for HO management:

- No Remove flag: eNodeB shall not remove the NR from the NRT if this flag is set.
- No Handover flag: No HO allowed with this NR when set
- No X2 flag: X2 should not be used for HO

As an alternative or a complement to the distributed mechanism, the operator’s NM may

- Pre-configure the NR table using centralised automated tools,
- Add/delete NR automatically to fine tune NR based on PM counters,
- Modify NR attributes,
- Control the behaviour of the NR by whitelisting, blacklisting and prohibiting X2.

The O&M can upload the NRT of the eNB it manages. This provides the possibility of a global optimization of the NRT of several cells. Examples of such optimization are neighbour ranking or pruning of unused NR.

The operator may also decide to deactivate the automatic ANR function in eNB. In this case, the ANR function operates in a centralised way without the direct involvement of eNB. Information available at the

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**Figure 2-2: Automatic Neighbour Relation function**

In distributed implementation, eNBs build their NRTs using measurements from the UE they serve. UEs report the PCI (Physical Cell Identity) of the cells that they have detected to their serving eNB. When the eNB does not recognize the PCIs, it may require the UE to provide additional information, such as the ECGI (E-UTRAN Cell Global Identifier), as well as other complementary information related to the cell detected.

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The O&M can upload the NRT of the eNB it manages. This provides the possibility of a global optimization of the NRT of several cells. Examples of such optimization are neighbour ranking or pruning of unused NR.

The operator may also decide to deactivate the automatic ANR function in eNB. In this case, the ANR function operates in a centralised way without the direct involvement of eNB. Information available at the
NMS (e.g. HO KPI history, Call Trace Events, etc.) can be used by the O&M to build the NRTs of the eNB it manages. In this case the NRT are downloaded to each eNB and imposed.

2.3 Mobility Robustness Optimization

Mobility Robustness Optimisation (MRO), also referred to as Handover Optimisation, is a SON feature designed to automatically reduce number of radio link failures (RLFs) and ping-pongs due to poor handover parameters settings. RLFs can be caused due to handovers being triggered too late or too early or to a wrong cell. As reduction in RLFs by manipulating handover parameters creates a trade-off with ping-pong effect, MRO is also expected to mitigate RLF and ping-pong trade-off.

Detection of too late HOs, too early HOs and HO to wrong cells utilises X2 signalling messages which enable indication of the RLF event to the appropriate eNB. Ping-pong HOs can be detected via information contained in the messages used during HO procedure, either via X2 or S1.

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Description / Note</th>
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<tbody>
<tr>
<td>Rate of HO failures</td>
<td>All failure cases</td>
</tr>
<tr>
<td>Rate of too early HO failures</td>
<td>RLF occurs within short time after UE successfully connected to the target cell. UE re-establishes the connection in the source cell.</td>
</tr>
<tr>
<td>Rate of too late HO failures</td>
<td>RLF occurs in the source cell before HO was initiated or during HO procedure. UE re-establishes the connection in a cell different than the source cell.</td>
</tr>
<tr>
<td>Rate of HO failures to wrong cell</td>
<td>Either RLF occurs within short time after UE successfully connected to the target cell or UE fails to connect to the target cell leading to RLF. UE re-establishes the connection in a cell other than the source cell or the target cell.</td>
</tr>
<tr>
<td>Rate of ping-pong HOs</td>
<td>Consecutive HOs between a pair of cells within a pre-configured time frame.</td>
</tr>
<tr>
<td>Rate of rapid HOs</td>
<td>Consecutive HOs from the source cell to the target cell and then from the target cell to a third cell within a pre-configured time frame.</td>
</tr>
</tbody>
</table>

Table 2-1: Metrics monitored by MRO

<table>
<thead>
<tr>
<th>Event</th>
<th>Summary</th>
<th>Tuneable Parameters</th>
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<tbody>
<tr>
<td>A3</td>
<td>Neighbour becomes offset better than serving</td>
<td>Ofn, Ofp, Ocn, Ocp, Hys, Off, timeToTrigger</td>
</tr>
<tr>
<td>A4</td>
<td>Neighbour becomes better than threshold</td>
<td>Ofn, Ocn, Hys, Thresh, timeToTrigger</td>
</tr>
<tr>
<td>A5</td>
<td>Serving becomes worse than threshold1 and neighbour becomes better than threshold2</td>
<td>Ofn, Ocn, Hys, Thresh1, Thresh2, timeToTrigger</td>
</tr>
</tbody>
</table>

Table 2-2: Tuneable parameters for intra-LTE MRO [6] \cite{19}

\cite{6} Reference [6] is corrected according to reference [19].
Table 2-3: Tuneable parameters for inter-RAT MRO [6]

<table>
<thead>
<tr>
<th>Event</th>
<th>Summary</th>
<th>Tuneable Parameters</th>
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<tr>
<td>B1</td>
<td>Inter RAT Neighbour becomes better than threshold</td>
<td>Ofn, Hys, Thresh, timeToTrigger</td>
</tr>
<tr>
<td>B2</td>
<td>Serving becomes worse than threshold1 and inter RAT neighbour becomes better than threshold2</td>
<td>Ofn, Hys, Thresh1, Thresh2, timeToTrigger</td>
</tr>
</tbody>
</table>

2.4 Mobility Load Balancing

Mobility Load Balancing (MLB) is a SON feature which allows network elements that handle traffic (either user or signalling), to share the load. The goal is to distribute user traffic across system radio resources to improve end-user experience and achieve higher system capacity. This can be accomplished by one or a combination of algorithms that perform balancing of cell load.

These MLB SON algorithms for offloading traffic from one element to another can include intra-carrier, inter-carrier, or inter-technology resources, as long as there is software intelligence to ensure radio admission and continuity of service on the target element. Traffic offloading is accomplished by modification of cell reselection or handover threshold parameters, which can require coordination with competing SON algorithms within multi-vendor environment to ensure robustness and stability of system.

MLB algorithms can be implemented either in a distributed or in a centralised way.

In LTE, the UE initiates a handover procedure, based on signal and time thresholds defined and transmitted by the serving cell. These are the HO hysteresis, Time To Trigger (TTT) and the parameter cellIndividualOffset. The latter is a vector quantity sent by the serving cell, which contains the offsets of the serving and neighbour cells that all UEs in this cell must apply in determining whether the measured RSRP satisfies the event A3 condition. When event A3 condition is satisfied, the UE sends a measurement report to trigger the handover.

Figure 2-3 shows the message exchanges involved in MLB.
The challenge is to configure these parameters in optimal manner keeping handover success rate and the dropped call rate close to their targets. This is especially difficult in urban areas and HetNets where UE mobility profile can lead to ping-pongs.

Traffic load balancing between layers and cells will depend amongst other factors on the UE average mobility condition and the topology of the network and its characteristics.

2.5 Coverage and Capacity Optimization

Coverage and Capacity Optimisation (CCO) SON function aims to achieve (1) a consistent coverage with minimised inter-cell interference and (2) optimal capacity to the cell users. These two goals are inter-linked and often at odds with each other. CCO function purpose is to deliver optimised coverage and capacity by adjusting transmits power, antenna tilt, etc.
Tuneable Parameter | Description / Note
---|---
Downlink transmit power | Downlink carrier transmit power over common channels, traffic channels, control channels
Antenna tilt | Adjust the phase of antenna elements (Electrical method) or adjust the tilt angle physically (Mechanical method). Note that antenna tilt may be typically adjusted slowly due to its big adverse effect if it is improperly adjusted.

Table 2-4: Tuneable parameters for CCO [6]

CCO may use load measurements of neighbour cells obtained via the X2 Resource Status Reporting procedure.

3 PERFORMANCE METRICS AND TARGETS

A set of recommendations and requirements on SON and O&M developed by the NGMN can be found in [2]. This input constitutes valuable guidelines to establish the metrics to measure the SON features performance in multi-vendor configurations.

Table 3-1 provides the performance metrics that apply to each SON function.

<table>
<thead>
<tr>
<th>Top Metrics</th>
<th>Quality of Experience</th>
<th>Throughput</th>
<th>Operational Efficiency</th>
<th>Energy Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANR</td>
<td></td>
<td></td>
<td>Reduces human intervention</td>
<td></td>
</tr>
<tr>
<td>MLB</td>
<td>Setup Success Rate QoS, call drops reduction</td>
<td>Avg. &amp; cell edge gain</td>
<td>Reduces human intervention (HO triggers)</td>
<td></td>
</tr>
<tr>
<td>MRO</td>
<td>Reduces drops, Avoid unnecessary HO (ping pong)</td>
<td></td>
<td>Reduces human intervention</td>
<td></td>
</tr>
<tr>
<td>PCI opt</td>
<td>Reduces drops</td>
<td></td>
<td>Reduces human intervention</td>
<td></td>
</tr>
<tr>
<td>CCO</td>
<td>Coverage Quality Setup success rate</td>
<td>Tput distribution</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3-1: SON metrics

Four categories of metrics have been selected. They constitute the most relevant criteria to measure performance in multi-vendor mode.

In multi-vendor operation a certain (limited) level of performance degradation is tolerated with respect to single-vendor operation. This level of degradation needs to be specified for each metric of each SON feature.

The ideal method to assess the level of degradation would be to use single-vendor configurations as reference. In this objective, the methodology would be to:

- Perform measurements for each vendor separately, select the best performance metrics of each vendor
- Perform the same measurements in multi-vendor configuration
• Compare measurements, and check versus the acceptability criteria

This approach appears to be long and complex, and perhaps unfeasible in certain cases, since all vendors may not have all products needed to perform all essential tests within a single-vendor configuration.

In view of simplifying the process, the methodology will be to measure performance improvements of each SON feature by comparing cases with SON feature activated versus SON feature deactivated. Absolute minimum performance improvements will be used as acceptability criteria.

The reference will be typical performance values and remain to be agreed between the project members.

Figure 3-1 shows the SON interactions within the macro and the small cells layers, and between the small cell and the macro layers.

![Diagram showing SON interactions between small cells and the macro layer]

**Figure 3-1: SON interactions between small cells and the macro layer**

The current study focuses on the interactions between the macro cell layer and the small cell layer, and may be extended in a future phase to the other interactions. Multi-vendor small cells deployments appear to be a realistic scenario, and should be the next study priority.

The SON features indicated in bold in Figure 3-1 designate the most important features in terms of criticality of the problem solved, or importance of the performance improvement. They do not indicate priorities in the study. Eventually all items of the list will be covered by the study.

## 4 REFERENCE ARCHITECTURE

The reference in multi-vendor architecture is described is shown in Figure 4-1.

A number of interfaces have been defined by the 3GPP. The description of this section will be limited to the interfaces of interest for multi-vendor SON analysis.
3GPP Management Architecture

Centralized SON and Distributed SON

RAN control interface
- X2 used to connect an eNB with its neighbours. Typically, two kinds of information are exchanged over this interface: load or interference related information, and handover related information. The X2 application protocol includes the support of some of the SON functions.

Management interfaces
- Itf-N (a.k.a. Type 2) between the Element Manager (EM) and the Network Manager (NM)
- Type 1 between the Network Elements (NEs) and the Element Manager (EM)

The 3GPP management specifications focus on Type 2 and to a lesser extent on Type 1 management interfaces. Typically, EMs are supplied by the same vendor as eNBs. This is why Type 1 interface can be proprietary. Type 1 interface will therefore not be used for multi-vendor interoperability.

The present interoperability analysis will solely rely on X2 and Itf-N.

Ownership model (assumption held throughout the study):
- eNB, EM and DM are supplied by the same vendor (vendor A and vendor B as indicated in Figure 4-1)
- NM is typically owned by the operator, the SON functions when centralised in NM, can be supplied by the vendors, or by a third party.
5 IMPLEMENTATION OPTIONS

This section identifies the types of multi-vendor SON architecture and multi-vendor interaction points (i.e. interfaces) for each SON feature based on 3GPP TS 32.522 [6]. The latter sections discuss interoperability issues and its recommended practices based on the assumptions of SON architectures identified in this section.

The Figure 5-1 gives a general depiction of Network architecture used to identify the possible location of SON algorithms and make general assumption on the potential interworking, based on the location of these function.

The green sub-system controls macro cell and the red sub-system controls Small cell.

Possible location of the SON functions:

- Centralised: At NM level, SON operates through the Itf-N interface. The element manager (EM) translates operations at the Itf-N to corresponding actions at Type 1 interface.
- Distributed (in the context of this document): At the DM (Domain Manager) level or at eNB level, Itf-N or X2 can be used for the communications of the SON functions between vendors, depending on the SON function considered, and implementation choices. This includes the EM centralized architecture as described in 3GPP TS 32.500.

As a Macro cell and Small cell in this case are controlled by different eNB-EM sub-systems the following combinations of inter-working should be possible:

<table>
<thead>
<tr>
<th>No</th>
<th>Location of a SON Function</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>eNB-EMS Sub-system</td>
<td>eNB-EMS Sub-system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>eNB-EMS Sub-system</td>
<td>eNB-EMS Sub-system</td>
<td>NM for Vendor A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>eNB-EMS Sub-system</td>
<td>eNB-EMS Sub-system</td>
<td>NM for Vendor B</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>NM for both A and B</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-1: Vendor architecture combination options
The pros and cons of different implementation options are well documented in several papers, and will not be repeated here.

5.1 Architecture Option 1: Distributed SON for Small Cell and Macro Cell

The architecture in Figure 5-2 assumes that a given SON function is located at EM or eNB level for both vendors. In this case each vendor would have implemented standardised 3GPP X2 interface [7] and will be able to support most of the X2 exchanges for inter-working purposes.

The main challenges for vendor coordination over X2 in this architectural scenario are:

- Alignment of support of 3GPP optional signalling to enable other vendor algorithms.
- Alignment of exchanged value meanings
- Alignment of timing for function monitoring and reporting.

5.2 Architecture Option 2: Macro Cell Centralised SON and Small Cell Distributed SON
The architecture in Figure 5-3 assumes that a given SON function is located at EM or eNB level for Small Cell vendor (B) and at NM level for Macro Cell vendor (A).

In this case Small Cell vendor would have implemented standardised 3GPP X2 interface [7] and will be able to support most of the X2 exchanges for inter-working purposes, however Macro Cell vendor may or may not have supported SON related X2 signalling and/or IEs.

The main challenges for vendor coordination over X2 in this architectural scenario are:

- Alignment of exchanged value meanings
- Alignment of timing for function monitoring and reporting
- Alignment of support of 3GPP optional measurement reporting to enable other vendor algorithms.
- Support and alignment of X2 and Itf-N information exchange, which may not be standardised

5.3 Centralised NM-based SON for Small Cell and Macro Cell

Figure 4-1 shows location of Centralised NM-based SON functions within the Management reference model of 3GPP TS 32.101 [12]. It is located at the NM (Network Manager) level and operates via Itf-N Type 2 interface. The Element Manager (EM) provides mapping of SON operations to certain management actions at the NE (RNC or eNodeB) over the Type 1 interface.

Centralised NM-based SON manager monitors input data such as performance measurements, fault alarms, notifications etc. After analysis of the input, optimization decisions are made according to the certain algorithms. Finally, corrective actions are triggered at the affected network nodes.

According to this concept, the NM portion of Self-Optimization Monitoring and Management Function performs necessary monitoring and limited interaction capabilities to support an automated optimization, as well as related IRPManager functionality.

The following Figure 5-4 shows many-to-many “mesh” relationship between centralised SON functions and network parameters
Itf-N interface specifications provide for wide variety of information sources (measurements, alarms, traces etc.) and of managed OAM parameters, which allows for variety of SON functions that can be implemented at the NM layer. It is important to note that design of Centralised SON requires high tolerance to failures and accurate analysis of cost / performance issues to avoid overloading of the centralised SON controller.

3GPP is using concept known as Integration Reference Point (IRP) described in the documents TS 32.103 [16] and 32.150 [17]. Specification of every IRP covers a set of operations and notifications for a specific telecom management domain such as alarm management, configuration management, etc.

The following table provides a list of the most important IRPs and the corresponding 3GPP specifications.

<table>
<thead>
<tr>
<th>Specifications</th>
<th>IRPs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.64x</td>
<td>UTRAN NRM IRP</td>
<td>The UTRAN NRM IRP defines an IRP through which an IRPAgent can communicate Configuration Management information to one or several IRPManagers concerning UTRAN specific network resource, by reusing relevant parts of the Generic NRM IRP in 32.62x series.</td>
</tr>
<tr>
<td>32.76X</td>
<td>E-UTRAN NRM IRP</td>
<td>The E-UTRAN NRM IRP defines an IRP through which an IRPAgent can communicate Configuration Management information to one or several IRPManagers concerning E-UTRAN specific network resource, by reusing relevant parts of the Generic NRM IRP in 32.62x series.</td>
</tr>
</tbody>
</table>
| 32.52X         | SON POLICY NRM IRP                | The SON Policy NRM IRP defines an IRP through which an IRPAgent can communicate Configuration Management information to one or several IRPManagers concerning Self-Organising Networks Policies. Currently the following SON use cases are supported by this NRM IRP:  
  - SON Self-Optimization Management (requirements determined by TS 32.521 [18])  
  - SON Self-Healing Management (requirements determined by TS 32.541, [13])  
  - Energy Saving Management (requirements determined by TS 32.551, [14]) |

Table 5-2:

The following table outlines most important Performance Measurements:

<table>
<thead>
<tr>
<th>Specifications</th>
<th>IRPs</th>
<th>Notes</th>
</tr>
</thead>
</table>
Specifications | IRPs | Notes
---|---|---
32.43x | PM File Format | This set of specifications describes the general semantics of performance measurement result and collection. It defines the report file format, report file conventions, and the file transfer procedure.
32.451, [15] | E-UTRAN KPI's | This specification defines requirements (business level requirements, specification level requirements and use case descriptions) related to KPIs for E-UTRAN.

Table 5-3:

Note: MDT trace functionality added in 3GPP Rel’10 can be used to collect Radio and performance measurements performed by mobiles, for example for Coverage and Capacity Optimisation. MDT allows tracing of UE’s operations for both UTRAN and E-UTRAN from any vendor and can be particularly helpful for multi-vendor SON.

As can be seen in the following Figure 5-5, the Centralised NM-based SON architecture provides for interoperability between a 3rd party SON solution and a RAN of any vendor as well as for simultaneous SON operations on RAN devices from different vendors, arbitrarily mixed in the network. Operations over fully standardized interface (in this case Itf-N) provide for interoperability between pieces of equipment from different vendors.
6 INTEROPERABILITY ISSUES AND RECOMMENDED REMEDIES

This section identifies potential interoperability issues with multi-vendor SON deployment for each SON feature and the proposed remedies.

6.1 PCI Optimization

To prevent conflicts in multi-vendor deployments, the simplest solution could be to partition the PCI space between the different vendors. However, in dense small cell HetNet deployments, the number of PCIs available to each vendor after such partitioning may be too limited to resolve intra-vendor PCI conflicts.

In a NM-centric mode, in which PCIs are allocated by the operator (and eNBs are slaves), such partitioning method is not needed.

In a distributed mode, in which eNBs autonomously allocate PCIs, if the partitioning of the PCI space is not used, there might be a need to solve remaining allocation conflicts. NM may have a role in this resolution.

6.1.1 Distributed Implementation

6.1.1.1 Interface related issues

The following X2 procedures/messages are used for PCI optimisation:

- X2AP X2 Setup
  - X2 SETUP REQUEST
  - X2 SETUP RESPONSE
- X2AP eNB Configuration Update
  - ENB CONFIGURATION UPDATE

These messages contain the ECGI, PCI and EARFCN of the sending eNB’s served cells and their neighbour cells. The receiving eNB can use these messages to detect PCI collision and PCI confusion.

Note that PCI collision and PCI confusion may be detected by other means, e.g. reported by UEs via ANR measurements.

When an eNB decides to modify a PCI of one or more of its served cells, it should indicate the change to all eNBs with which it has an existing X2 connection. If the PCI modification is indicated via including the modified cell’s E-CGI in both Served Cells to Delete and Served Cells to Add, this may result in deletion of the corresponding NR in the receiving eNB and there may be a delay before the NR is added again via ANR functionality. Therefore, the PCI modification should be indicated via the Served Cells to Modify IE in X2AP: ENB CONFIGURATION UPDATE.

Recommended practice: eNB should use the IE Served Cells to Modify in X2AP: ENB CONFIGURATION UPDATE to indicate a change of PCI of one of its served cells.

6.1.1.2 Algorithm Coherence related issues

When PCI conflicts are detected, due to the disruptive nature of PCI reassignment, it is preferable that only one eNB performs PCI reassignment if possible. Different vendors can apply different proprietary mechanisms, potentially resulting in situations where both nodes perform PCI reassignment and/or in situations where neither node performs PCI reassignment. Therefore, it is necessary to have a policy which unambiguously defines which eNB should reassign PCI in case of PCI collision/confusion.
Recommended practice: it should be confirmed by the operator that the policy for PCI reassignment is aligned between vendors.

One policy is that PCI reassignment is performed by the eNB with the larger ECGI.

Recommended practice: PCI reassignment should be performed only by the eNB with the larger ECGI.

It should be noted that prevention of inter-vendor PCI collision is possible via partitioning of the available PCIs, assigning non-overlapping PCI subsets to each vendor. However, this is not assumed to be an approach which is acceptable to all operators.

6.1.2 Centralised Implementation

Even though the centralised NM-based SON addressed in Section 5.3 provides optimal PCI allocations in multi-vendor deployment scenario, operators may choose to utilize the distributed SON functions at eNBs. The typical solution to avoid PCI collisions between different vendor eNBs in HetNets is to assign mutually exclusive PCI sets to different vendors. In this way, the probability of PCI collision is guaranteed to be very low. However, there still are issues with PCI optimization when distributed SONs are adopted in multi-vendor deployment scenario.

First, there can be PCI confusion between macro cells and small cells. Each vendor’s EMS may assign PCIs avoiding PCI collisions and confusion within its managing eNBs and the PCI confusion can happen as shown in Figure 6-1. Since the NRT distinguishes neighbour by the Target Cell Identifier (TCI), which corresponds to the ECGI and PCI, the macro eNB may continue support handovers (HOs) to small cell by requesting UEs to read and report ECGI whenever they detect the confused PCI. However, it requires layer-1 control signalling and also brings delays in the handover procedures, which may lead to higher handover failure rates eventually.

Second, there can be high interference issues between macro cells and small cells when ‘PCI mod 3’, ‘PCI mod 6’, or ‘PCI mod 30’ rules are not satisfied. If these rules are not satisfied, their Primary Synchronization Signals, or Reference Signals used for channel estimation at UE, or uplink Demodulation Reference Signals may interfere with each other, respectively.

Figure 6-1: PCI Confusion in Multi-vendor Deployment

High handover failure rate or other KPIs triggers the centralised SON at the OSS layer to identify and resolve addressed issues. Based on HO KPI history and call trace events, the centralised SON identifies the cells
that cause PCI confusion and assign new PCI value to the cell causing PCI confusion, overriding the original PCI assignment from its EMS. Also, ‘PCI mod 3’, ‘PCI mod 6’, and ‘PCI mod 30’ rules will be checked and found optimal PCI values can be newly assigned to corresponding cells.

6.2 Automatic Neighbour Relation

Two, possibly complementary and non-exclusive, operation modes are described in section 2.2.

The distributed implementation does not involve any exchanges between eNB. The X2 setup that may follow the discovery of a new neighbour is a basic X2 procedure not related to the ANR function, and is assumed to be tested separately. Monitoring and control function implemented in the NM requires interoperability on the Itf-N for a number of operations related to NRTs management.

The centralised implementation mode requires additional interoperability on Itf-N for the delivery of measurements (e.g. HO KPI history, possibly combined with Call Trace Events)

6.2.1 Distributed Implementation

6.2.1.1 Interface related issues

6.2.1.1.1 Neighbour Relation Signalling

The following X2 procedures/messages are convey neighbour relation information:

- X2AP X2 Setup
  - X2 SETUP REQUEST
  - X2 SETUP RESPONSE
- X2AP eNB Configuration Update
  - ENB CONFIGURATION UPDATE

The sending eNB can use these messages to report updates to the neighbour relations (NRs) of its served cells. The receiving eNB can use the NR information as input to the ANR function.

There is no identified IOT issue with these messages.

6.2.1.1.2 X2 Connectivity

As a result of addition of a neighbour relation, an eNB may initiate the TNL Address Discovery procedure which uses the following S1AP procedures:

- S1AP eNB Configuration Transfer
  - eNB CONFIGURATION TRANSFER
- S1AP MME Configuration Transfer
  - MME CONFIGURATION TRANSFER

These messages can convey a request for the TNL address suitable for SCTP connectivity. The messages are relayed by the MME. The same messages are used for conveying the response.

However, the TNL Address Discovery procedure is not a pre-requisite for establishment of an X2 interface.

Recommended practice: The eNBs should be able to create SCTP and X2AP connections with each other at any time.
6.2.1.2 Algorithm Coherence related issues

Each NR is unidirectional. However, if bidirectional MLB to be supported between cell pairs, it is necessary for the NRs to be symmetrical.

Recommended practice: if support of bidirectional MLB is needed, a mechanism to achieve symmetrical NRs is required.

6.2.2 Centralised Implementation

The centralised NM-based SON creates the initial NRTs for eNBs and continuously updates the NRTs based on HO KPIs and call trace events data. When the network area is HetNet with small cells and macro cells provided by different vendors, those small cells and macro cells may be managed by different EMS and hence the configuration changes of cells that belong to other EMS may not propagate to all the neighbour cells correctly. With this reason, popup-and-disappear small cells in HetNet might bring frequent HO failures due to ECGI or TAC mismatch in the NRT.

The OSS layer SON uses the following inputs for determining the optimal neighbour lists for each cell within the network: detected neighbour set reporting, neighbour directed HO attempts and successes, cell level aggregate HO attempts and successes, call trace events, general ANR policies, maximum neighbours on list, white list/black list, cell location, antenna azimuth and max distance. The OSS layer SON also identifies popup-and-disappear neighbour from narrow LOS link, utilizing HO KPIs and geographical prediction tools to set those neighbours in black list.

Figure 6-2 shows the centralised SON at NMS corrects PCI confusions and also mediates between EMS from different vendors by updating configurations and NRTs. The centralised SON at OSS layer retrieves the changed configuration of the cell and update NRTs of other vendor’s eNBs that have the corresponding small cell as neighbour. When there is a conflict between SON functions in the eNB and the OSS layer SON, the SON Coordination Function at NM layer may be responsible for conflict prevention and resolution as described in 3GPP TS 32.522 [6].

6.3 Mobility Robustness Optimization

6.3.1 Distributed Implementation
6.3.1.1 Interface related issues

6.3.1.1.1 Ping-pong Detection

In order to detect ping-pong, an eNB can use the UE History Information IE in the S1AP HANDOVER REQUEST or X2AP HANDOVER REQUEST messages. This IE contains the cell stay time for each cell the UE has visited during its current connection.

**Issue#1**

A ping-pong is detected if a handover occurs from cell A to cell B and back to cell A, with the cell stay time in cell B being less than a pre-determined Minimum Time-of-Stay (MTS). If the setting of MTS is not aligned among vendors, the number of ping-pong HOs from source cell can be greatly different from that of ping-pong HOs from target cell.

Recommended practice: the value of MTS should be configurable by the operator and aligned amongst vendors.

**Issue#2**

The range and granularity of the cell stay time defined by 3GPP is INTEGER (0..4095). It should be aligned amongst vendors how the cell stay time is rounded, i.e. rounded down or to nearest integer, etc.

For example, for a cell stay time of 1.5 seconds, vendor A may round down to 1 second, while vendor B may round up to 2 seconds. If the value of MTS is 1 second, vendor A would detect ping-pong and vendor B would not.

Note that the issue is resolved in 3GPP Rel-11 by improved granularity (0.1 second) of the cell stay time.

Recommended practice: alignment of the rounding method of cell stay time between vendors may be needed if improved cell stay time granularity is not supported.

6.3.1.2 Algorithm Coherence related issues

**Issue#1**

If the timescale is significantly shorter for vendor A than for vendor B, then several handover configuration updates may be triggered by vendor A, which may restrict the handover updates possible by vendor B. As a result, the rate of handover problems from eNB(b) to eNB(a) may not be reduced as much as those from eNB(a) to eNB(b).

For example, if there are many Too Late HOs between vendor A’s eNB and vendor B’s eNB in both directions, both eNBs may wish to decrease the handover trigger in order to mitigate the handover failure rate. If vendor A’s MRO is operating on a shorter timescale than vendor B’s, vendor A’s MRO may decrease the handover trigger multiple times for each time vendor B’s MRO decreases the handover trigger.

Recommended practice: The timescale of operation for MRO should be configurable by the operator.

**Issue#2**

A similar problem can occur if the neighbouring eNBs apply different amount of change to the handover trigger. The eNB making the larger changes can reduce the opportunities for the neighbour eNB to make any changes of its own.

Recommended practice: The amount of change applied to the handover trigger should be configurable by the operator and aligned to avoid extreme differences between vendors.
6.4 Mobility Load Balancing

6.4.1 Distributed Implementation

6.4.1.1 Interface related issues

6.4.1.1.1 Load Estimation and Resource Status Exchange

In the Load Estimation step, the source cell in eNB1 will perform the evaluation of its load based on some proprietary mechanism, and try to determine whether it is necessary to perform the load balancing. The criteria for performing load balancing not defined in 3GPP specifications. As a result, eNB may perform the Resource Status Exchange procedure and the load balancing when it may not be necessary, or skip it when it is needed. For example, some eNBs may have many Non-GBR bearers, taking up all remaining available PRB resources and thus resulting in a cell load, which may trigger the Resource Status Exchange procedure, and consequently load balancing actions when it may not be needed, considering that the PRB usage for Non-GBR traffic could be reduced. In this case, the load estimation is not so precise to reflect the real load information carried in the eNB.

The Resource Status Exchange procedure has been specified by 3GPP. However, some optional IEs that are important for load balancing may not be exchanged. Furthermore, specific IEs such as the capacity value are not precisely defined, e.g. whether the capacity value has to consider the characteristics of non-GBR traffic.

An eNB should support the following X2AP procedures/messages for exchange of load:

- X2AP Resource Status Reporting Initiation
  - RESOURCE STATUS REQUEST
  - RESOURCE STATUS RESPONSE
  - RESOURCE STATUS FAILURE
- X2AP Resource Status Reporting
  - RESOURCE STATUS UPDATE

3GPP TS 36.423 (X2AP) [7] defines the RESOURCE STATUS UPDATE message containing the following measurement information elements (IEs) for reporting of cell load (highlighted in green):

<table>
<thead>
<tr>
<th>IE/Group Name</th>
<th>Presence</th>
<th>Range</th>
<th>IE type and reference</th>
<th>Semantics description</th>
<th>Criticality</th>
<th>Assigned Criticality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Type</td>
<td>M</td>
<td>9.2.13</td>
<td>YES</td>
<td>ignore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eNB1 Measurement ID</td>
<td>M</td>
<td>INTEGER (1..4095,...)</td>
<td>YES</td>
<td>reject</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eNB2 Measurement ID</td>
<td>M</td>
<td>INTEGER (1..4095,...)</td>
<td>YES</td>
<td>reject</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell Measurement Result</td>
<td>1</td>
<td>YES</td>
<td>ignore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;Cell Measurement Result Item</td>
<td>1 to maxCellineNB</td>
<td>EACH</td>
<td>ignore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;Cell ID</td>
<td>M</td>
<td>ECGI</td>
<td>9.2.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;Hardware Load Indicator</td>
<td>O</td>
<td>9.2.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;S1 TNL Load Indicator</td>
<td>O</td>
<td>9.2.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;Radio Resource Status</td>
<td>O</td>
<td>9.2.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;Composite Available Capacity Group</td>
<td>O</td>
<td>9.2.44</td>
<td>YES</td>
<td>ignore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt;ABS Status</td>
<td>O</td>
<td>9.2.58</td>
<td>YES</td>
<td>ignore</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6-1: X2AP RESOURCE STATUS UPDATE
Issue#1

The type of load information can be requested by the source eNB, via the Report Characteristics IE in the X2AP message RESOURCE STATUS REQUEST. If the target eNB is capable of providing the requested type of load information, it shall initiate the corresponding measurement and send RESOURCE STATUS RESPONSE. Otherwise, it shall send RESOURCE STATUS FAILURE, or alternatively, in case of partial failure, the target eNB may send RESOURCE STATUS RESPONSE with failure cause.

The failure of Resource Status Reporting Initiation due to non-supported load information by the target eNB can be avoided by offline agreement between the operator and their vendors regarding which types of load information shall be used.

Recommended practice: The supported types of load information should be configurable by the operator such that they are aligned between the vendors.

Possible (more complex) practice: a minimum set of load measurement types shall be supported by all vendors (e.g. PRB Usage). If a source eNB requests a load measurement type outside this minimum set, and the target eNB fails to initiate the measurements, the source eNB may retry with the minimum set. Alternatively, the load measurement types outside of this set can be agreed to be supported offline between vendors/operator.

Issue#2

Hardware Load Indicator and S1 TNL Load Indicator can take 4 values (low, mid, high, overload). The definition of HW/S1 TNL Load is not standardised, neither is how to map a measured HW/S1 TNL Load to the HW/S1 TNL Load Indicator value. It is expected that alignment on the definition of HW/S1 TNL Load will be performed offline and the mapping from HW/S1 TNL Load to HW/S1 TNL Load Indicator will be based on OAM configuration.

Note that HW load is particularly vendor specific as it depends on potential bottlenecks of a vendor specific HW architecture. Hence, alignment of the HW Load may be only rough.

PRB (Physical Resource Block) usage is carried in the Radio Resource Status IE. The PRB usage definition is standardised in 3GPP TS 36.314 [10], therefore no interoperability problems associated with this load measurement type are expected.

Composite available capacity (scaled 0 to 100) can be used for carrying any combined, operator-specific load metric.

Recommended practice: The calculation formula for composite available capacity should be aligned offline between the operator and their vendors.

Issue#3

The metric used by SON LB can be calculated differently by each vendor. It is typically derived from a combination of Load Measurements from X2 and internal measurements.

Recommended practice: The SON LB metric calculation should be aligned offline between the operator and their vendors.

The following is a recommended practice of aligned SON LB metric:

The load estimation for each cell is obtained by accumulated load calculation of each user, indicated by the PRB usage. The uplink and downlink load estimation for each cell is obtained separately.

For GBR service, the PRB usage is calculated by the actual scheduled PRB usage, which could satisfy the GBR QoS requirements.

For non-GBR traffic, the PRB usage is calculated by the PRB usage that could satisfy the minimum experienced data rate, if the actual scheduled data rate is higher than the minimum experienced data rate.
data rate. Or, the PRB usage is calculated by the actual PRB usage, if the actual scheduled data rate is lower than the minimum experienced data rate. This minimum experienced data rate for non-GBR service is based on implementation and could be configured by operator.

The capacity value within the IE Composite Available Capacity Group should be obtained based on the load estimation and transmitted as mandatory IE.

Note: Other recommendations for alignment of SON LB metric are also possible.

6.4.1.1.2 UE Selection and Load Balancing Handover Procedure

The UE selection step defines which UE should be selected for load balancing. This should be based on implementation and operators’ policy.

The HO procedure executes the decision of load balancing, and the reuse of the current HO procedure is sufficient. The appropriate cause value should be clearly defined for the triggering reason and failure case of HO. Since the OAM of operator will track the statistics of each HO type and also the failure type, the unaligned cause values will lead to unclear analysis of the HO type statistics.

Recommended practice: the value of Cause IE in X2-AP: HANDOVER REQUEST message used for HO triggered by load balancing should be aligned amongst the vendors.

Note: Other recommendations for alignment of SON LB metric are also possible.

6.4.1.1.3 HO Parameter Negotiation

An eNB should support the following X2AP procedures/messages for handover parameter negotiation:

- X2AP Mobility Settings Change
  o MOBILITY CHANGE REQUEST
  o MOBILITY CHANGE ACKNOWLEDGE
  o MOBILITY CHANGE FAILURE

3GPP TS 36.423 (X2AP) [7] defines MOBILITY CHANGE REQUEST/ACKNOWLEDGE/FAILURE to enable a source eNB to propose handover parameter change to a target eNB.

Issue#1

The target eNB is free to accept or reject the proposed parameter change, but it should generally be accepted for multivendor operation. The main reason for failure may be that the proposed change exceeds the allowed range. Another reason for failure could be, for example due to OAM intervention.

Recommended practice: eNB should accept proposed handover parameter changes by a neighbour eNB, with the exception of the proposed change being outside the allowed range or reasons such as OAM intervention.

Issue#2

HO parameter negotiation is used to achieve a co-ordinated adjustment of the HO region between two cells to avoid ping-pong. In case of intra-frequency HO, it is likely that most vendors use the same HO event (e.g. A3) to trigger HO, and adjustments to HO parameters configuration as a result of HO parameter negotiation can be applied to this event, by adjusting e.g. the CIO. However, in case of inter-frequency HO, and especially in a HetNet environment, different vendors are more likely to employ different measurement events to trigger inter-frequency HO, for example, any of A3, A4 or A5 may be used to trigger HO, and additionally A2 may be used to control when inter-frequency measurements are performed. Depending on which
measurement events are used and which parameters (if any) are adapted by MLB, ping-pong avoidance may not be achieved via successfully negotiated HO parameter exchange.

For example, assume the macro cell uses measurement event A4 to trigger HO and the small cell uses a combination of A2 followed by A3. If the macro cell vendor applies a CIO change to event A4 to achieve offload to the small cell and proposes the opposite change to the small cell’s handover trigger, the small vendor may decrease the CIO for event A3. However, since event A2 does not consider CIO, the A2 event may be triggered in the small cell immediately after HO from the macro cell to small cell, potentially creating ping-pong conditions. This can happen if the A3 event criteria are fulfilled in most of the area served by the small cell, for example, due to a strong macro cell signal, and the effect of applying the CIO to event A3 in the small cell does not cause a significant delay in its triggering.

Recommended practice: vendors should exchange offline which measurement events are used to trigger HO and which parameters are adapted by MLB, with a view to ensuring that ping-pong can be avoided when performing HO parameter updates for MLB.

6.4.1.2 Algorithm Coherence related issues

Issue#1

The period of measurement analysis should be aligned. Over a short time period t, cell A may be more loaded than cell B, while over a longer period T within which period t occurs, cell B can be more loaded than cell A, which may potentially result in cell A and cell B triggering opposing load balancing actions.

Recommended practice: The load measurement analysis period should be aligned between vendors.

Issue#2

Furthermore, in order to achieve mutually exclusive triggering conditions based on comparison of a load metric, each vendor’s MLB algorithm should derive the metric in the same way.

Recommended practice: The load balancing metric should be aligned offline between operators and vendors.

It is additionally should be noted that the operator could control general policies, updated from the OSS to the Element Manager. An OSS-centric SON load balancing solution, controlled by the operator would further enable a multi-vendor operations, based on a high level SON running in the OSS, which communicates with every vendors’ Element Manager for RAN-level SON. OSS/SON would receive network KPI’s (e.g. load per cell or RAT, successful/unsuccesful connections, handover statistics) from the Element Managers, and would provide general policies (e.g. frequency, layer, cell or RAT priorities) to the vendors’ Element Managers.

6.5 Coverage and Capacity Optimization

It shall be noted that as defined in section 5 for the purpose of this document, the DM-level CCO is considered to be ‘distributed’ and NM-level CCO is considered ‘centralised’ whereas in TS32.522 [6] both are referred to as ‘centralised’.

6.5.1 Distributed Implementation

6.5.1.1 Interface related issues

An eNB should support the following X2AP procedures/messages for exchange of load:
- X2AP Resource Status Reporting Initiation
  - RESOURCE STATUS REQUEST
  - RESOURCE STATUS RESPONSE
  - RESOURCE STATUS FAILURE
- X2AP Resource Status Reporting
  - RESOURCE STATUS UPDATE

The same interface related recommended practices as for Load Balancing are applicable to CCO (issues #1-3 in section 6.4.1.1.1).

Note that these requirements are for a distributed CCO chiefly aimed at small cell capacity optimisation on a short timescale. The algorithm is different from a centralised CCO which is assumed to operate on a longer timescale.

6.5.1.2 Algorithm Coherence related issues

Issue#1

The target of CCO may be to optimise coverage, cell throughput, cell edge throughput, or a weighted combination of more than one of these targets. As a result, the target of CCO can be different between vendors, which may result in oscillations. Therefore, the optimisation targets should be shared between vendors. Based on this, each vendor’s CCO should adapt RF parameters considering the effect on the other vendor’s cells.

Recommended practice: based on knowledge of the neighbour cell’s optimisation policy, CCO should assess the impact on the other vendor’s cells before adapting RF parameters.

Issue#2

If simultaneous operation of CCO in different vendors occurs, it may result in a destabilised system. To avoid such an issue with architectures 2, it may be desirable to agree some prioritisation between centralised CCO and distributed CCO.

Recommended practice: Introduce operator configurable priorities between centralised CCO and distributed CCO.

6.5.2 Centralised Implementation

When the CCO of centralised SON at NM detects an area of the network in which coverage holes are present with undershoot cells in a given technology/frequency layer or areas of high overlap for cells of a given technology/frequency layer with overshoot cells, it fills the coverage hole or reduces cell footprints to lessen interference levels in overlapping areas by adjusting antenna parameters such as antenna tilt, half power beam width or antenna directions.

If CCO is operated at the EM per different vendor, each vendor may have different criteria in deciding overshooting or undershooting cells to trigger the CCO function to execute and the tilting amount for overshooting or undershooting cells might be different for different vendors as shown in Figure 6-3. Even when operators are deploying different vendor eNBs in separated areas, cells at the area boundary may have overshooting or undershooting issues with unbalanced antenna parameters. When small cells and macro cells are deployed in the same area to form a HetNet, the OSS layer SON finds optimal antenna parameters or transmit power of eNBs brings optimized coverage and capacity to the network.
Figure 6-3: Overshooting and undershooting cells

The OSS layer SON also identifies coverage holes or capacity holes (traffic hotspot) for further deployment of small cells.

7 CONCLUSION AND FUTURE WORK

This document provided high-level analysis of multi-vendor interoperability for deployment of SON features as PCI Optimisation, ANR, MRO, MLB and CCO in small cell populated LTE HetNet environment. The examples for both distributed and centralised SON architectures were discussed and potential problems highlighted with recommended practices for solving these problems listed.

It is believed that both SON architectures have potential to provide effective and efficient operations in terms of network performance and stability when recommended practices are understood and followed.

Further it is strongly advised that on basis of this analysis the proposed recommendations are put to practice in the follow up interoperability testing.

It is believed that as SON functionality and products mature there is a scope for future work on other SON features, such as:

- RACH Optimisation
- COC
- Energy Savings
- Etc.