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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

Heterogeneous Network is a collective term for a network comprising radio nodes of varying sizes and roles, from small base station nodes to big macro base station nodes. The purpose of using a heterogeneous network is to improve capacity and/or coverage, and to allow a variation of role over time for some of the nodes in order to optimize the overall performance.

Also small base station nodes may perform two roles and may switch role as necessary:

- acting as a coverage extender, most likely resulting in low traffic volumes in the node
- acting as a capacity booster, most likely resulting in high traffic volumes in the node

As the number of nodes to be managed will increase significantly by introducing small base station nodes, the management of the network must change.

Because of the large number of small base stations, it is essential to minimize the set of configuration parameters. It is also desirable to minimize the set of configuration parameters for the macro base stations. This means that there is no difference from minimization of configuration point of view for managing small or large base stations.

Because a significant proportion of the network traffic will carried by small base stations, the need for providing alarms and network KPIs are the same for small base stations as for big macro base stations. So also from PM and FM point of view there is no difference on the type of information that needs to be managed depending on the size of the base station.

What needs to change is the volume of data that needs to be decreased over Itf-N. However, different base stations are more important to manage in real time. In order to keep CAPEX and OPEX down, it must be possible to choose how the management info is propagated to the NMS. Different criteria can be used to have all information on line (as before), to only get information when the manger requests it, or something in between.

1 Scope

The present document investigates and makes recommendations on how management information can be selected by the manager over Itf-N for heterogeneous networks (see TR 21.905 [1]) nodes that are owned, deployed and maintained by the operator.

The nodes that are owned, deployed or maintained by residential users are out of scope of the present document, such as Home NodeBs, Home eNodeBs.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 41.001: "GSM Release specifications".

[3] 3GPP TR 36.932: "Scenarios and Requirements of LTE Small Cell Enhancements".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [x] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [x].

Active mode: Information passes Itf-N when the IRPAgent or the IRPManager have something to communicate.

Passive mode: No information passes the Itf-N unless when the IRPManager has requested it.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

None.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [x] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [x].

CAPEX Capital Expenditures

FM	Fault Management
HetNet	Heterogeneous Network
KPI	Key Performance Indicator
LTE	Long Term Evolution
O&M	Operation and Maintenance
OPEX	Operational Expenditures
PM	Performance Management

4 Concept

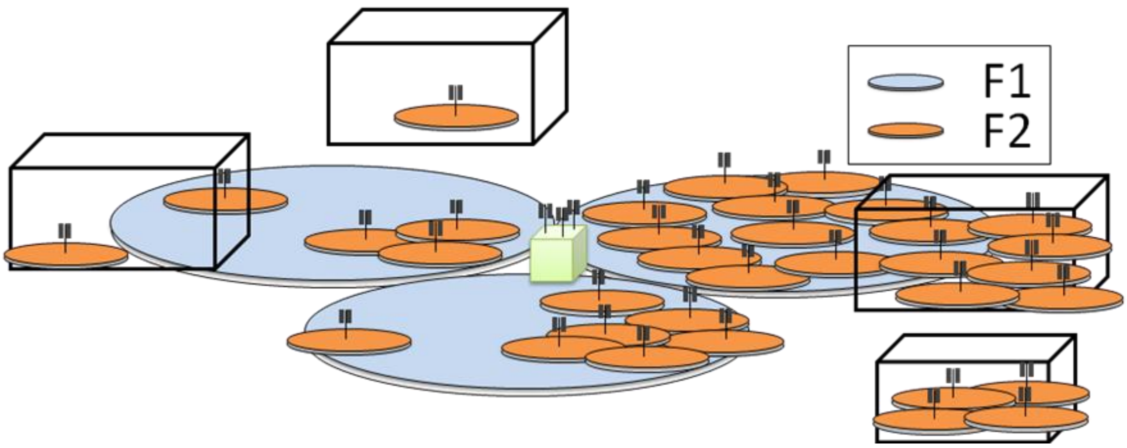
4.1 Deployment

4.1.0 General

A Heterogeneous Network consists of different types of Base Stations (BSs), supporting cells such as macro, micro and pico cells. These types of BSs will be mixed in an operating network.

4.1.1 Small cell deployment scenarios

Heterogeneous networks management should consider cells in a heterogeneous network, including small cells both with and without macro coverage, both outdoor and indoor small cell deployments and both sparse and dense small cell deployments. (See Figure 4.1-1)



NOTE 1: F1 and F2 are the carrier frequency for macro layer and local-node layer, respectively

Figure 4.1-1: Deployment scenarios of small cell

4.1.2 With and without macro coverage

Two typical HetNet small cell deployment scenarios are shown in Figure 4.1-1.

1) For capacity: Small cell nodes are deployed under the coverage of one or more than one overlaid macro cell layer(s) to act as capacity booster.

2) For coverage: Small cell nodes are not deployed under the coverage of any overlaid macro cell layer(s) to act as coverage extender.

4.1.3 Outdoor and indoor

HetNet management should consider both outdoor and indoor small cell deployments. The small cell nodes could be deployed indoors or outdoors, and in either case could provide service to indoor or outdoor UEs.

4.1.4 Sparse and dense

HetNet management should consider sparse and dense small cell deployments. As documented in TR 36.932 [3], in some scenarios (e.g., hotspot indoor/outdoor places, etc.), single or a few small cell node(s) are sparsely deployed, e.g. to cover the hotspot(s). Meanwhile, in some scenarios (e.g., dense urban, large shopping mall, etc.), a lot of small cell nodes are densely deployed to support huge traffic over a relatively wide area covered by the small cell nodes. The coverage of the small cell layer is generally discontinuous between different hotspot areas. Each hotspot area can be covered by a group of small cells, i.e. a small cell cluster.

5 Use Cases

1) A Mobile Network Operator needs to extend network capacity and coverage. The Mobile Network Operator accomplishes this by adding small nodes to the network.
2) A Mobile Network Operator wishes to add small nodes to the network, but is constrained by the fact that extra personnel are not available to install the small nodes. The Mobile Network Operator accomplishes this by allowing customers to install the small nodes and connect the small nodes to the network. The small nodes are automatically configured.
3) A Mobile Network Operator adds small nodes to the network, but is constrained by the fact that extra personnel are not available to maintain the small nodes. The Mobile Network Operator accomplishes this by using automated processes to manage the small nodes and to attempt to heal any faults.
4) A Mobile Network Operator adds small nodes to the network, but cannot justify collecting all the available data from the small nodes for reasons of bandwidth, OPEX and CAPEX. The Mobile Network Operator selects the degree of information that shall be provided by the small nodes, by using O&M policies.
5) A Mobile Network Operator designates a cell as important. This may be based upon factors such as lack of overlay coverage, high traffic levels, or high revenue. The Mobile Network Operator configures active mode for this cell.
6) A Mobile Network Operator designates a cell as not important. This may be based upon factors such as overlay coverage, low traffic levels, or low revenue. The Mobile Network Operator configures passive mode for this cell.
7) The importance of a cell may vary. At certain times, the cell may carry a lot of traffic, and therefore faults should be fixed as soon as possible. At these times, active mode is suitable. At other times, the cell may carry almost no traffic, and therefore faults do not need to be fixed immediately. At these times, passive mode is suitable. An automated system configures active or passive mode for this cell.

6 Requirements

6.1 Business level requirements

Operators shall be able to manage a much larger network than today with the same number of personnel.

Operators shall be able to manage a much larger network with same amount of performance data, even though the number of nodes has increased significantly.

6.2 Specification level requirements

The IRPAgent shall support different modes of operation, e.g. different active modes and possibly passive mode, according to IRPManager policies on the node/cell level.

The IRPAgent shall support the capability to allow the IRPManager to create, change and delete policies. On demand policies may include the objects (node or cell), time period for the node or cell to be in the passive mode and data filter for the IRPManager filtering the information (e.g. notifications or performance measurements) what it wants.

The IRPAgent shall support the capability to allow the IRPManager to get data (e.g. notifications or performance measurements) from the objects (node or cell) when needed.

7 Management solutions

7.1 On demand Management

In large networks, it is not practical to let the IRPAgents push all data to the IRPManager. The data may be performance data, trace data, notification log data and notifications carrying alarms and configuration data. Therefore, some IRPAgents may be instructed not to push data to the IRPManager. Instead, the IRPManager pulls data selectively as necessary.

The 3GPP Alarm IRP allows the IRPManager to avoid the use of notifications. The IRPManager may read the current alarm list from the IRPAgent.

The 3GPP Notification IRP allows the IRPManager to enable and disable the sending of notifications. Currently there is no mechanism in the 3GPP Notification IRP to fetch the notifications from the IRPAgent.

The 3GPP Notification Log IRP allows the IRPManager to fetch the notification log data from the IRPAgent.

The 3GPP Performance Management IRP allows the IRPManager to enable and disable the sending of measurements from the IRPAgent. Currently there is no mechanism in the 3GPP Performance Management IRP to fetch the measurements from the IRPAgent.

7.2 Classification of importance

7.2.1 Background

The traditional network management paradigm treats all nodes and all cells as equally important. As the size of the network increases, these traditional assumptions become less relevant. In a heterogeneous network, the variety of types of nodes and variety of sizes of cells will force the traditional assumptions to be questioned.

In a large network, the operator may need to evaluate which nodes or cells are most important. It is simply not practical to allocate equal resources to manage each node or cell. This is not a unique problem for heterogeneous networks, it is just that the need for prioritisation becomes more visible in a heterogeneous network.

For an operator to allocate management resources within the network, the operator must evaluate the importance of each node or cell in the network. The importance of each node or cell means different things to each operator. The importance may be based upon positive values (such as the revenue generated by the cell) or negative values (such as lack of coverage caused by a cell outage).

Each operator should have the freedom to define the importance of each managed entity according to the operator's own values.

It should be noted that the importance of a node or cell may be unrelated to the size of the node or cell.

In a large network, the results of the importance evaluation for each node or cell such as absolute value or relative value of "importance" may change over time either predictably or unpredictably. The cause of such changes could be periodic changes in traffic levels and patterns (e.g. time of day, day of the week, event based, etc...), instantaneous changes in coverage (e.g. deployment of new nodes, compensated and uncompensated outages, etc...), short term trends in user demands (e.g. VIP visits, promotional campaigns, etc...), long term trends in user demands (e.g. new applications with higher data requirements, growth of the user population, etc...), etc...

Static allocation of importance values may potentially degrade network performance and availability or result in waste of management resources and reduced savings in OPEX. Periodic manual re-evaluation of importance values may consume significant management resources. Dynamic allocation of importance values based on operator specified set of Key Performance Indicators (KPIs) should also be considered.

7.2.2 Analysis

In a large network, it is not practical for the operator to manually evaluate the importance of each node or cell in the network. Therefore, some automated process is probably required to evaluate the importance of each node or cell.

This automated process shall use evaluation criteria to evaluate a node or cell's importance. There are 3 general architectures to allocate responsibility between the IRPManager and the IRPAgent.

Case 1: The evaluation criteria of the node/cell's importance are created and used by the IRPManager.

Case 2: The evaluation criteria of the node/cell's importance are created by the IRPManager but are used by the IRPAgent.

Case 3: The evaluation criteria of the node/cell's importance are created and used by the IRPAgent.

Case 1 has the advantage that the result is more predictable, from the perspective of the IRPManager. The IRPManager has a finite set of resources (human and computational) available to manage the network. In case 1, the IRPManager can set the relative importance of nodes/cells to ensure that the management resources are fully utilised but not overloaded. In cases 2 and 3, the IRPAgents may classify a suitable amount of nodes/cells as important, or may classify too few nodes/cells as important resulting in under-utilisation of management resources, or may classify too many nodes/cells as important resulting in overload of management resources.

Case 2 has advantage that in a heterogeneous network, due to the huge amount of heterogeneous nodes, it's better to avoid the situation of bottle-neck handling in configuration management for the decision point, in a situation a cell's importance varies dynamically according to some dynamic mode evaluation criteria. Compared with the IRPManager, the IRPAgent is a better candidate for decision point, since its location is near to the network elements and will not be overloaded in dynamically adjusting the cell's importance in its domain. The cell's importance result (based on dynamic mode criteria) may be notified to the IRPManager, but should not be predicted by the IRPManager in advance.

The evaluation criteria of a node or cell's importance can be grouped into the following categories:

a) Static mode evaluation criteria

The static mode evaluation criteria are mostly created from the global view or high level of the network in a pre-planning way. When the cell's importance is determined by using the static mode evaluation criteria, the cell can keep the importance for a relatively long duration (e.g. a few of weeks or months). The examples of static mode evaluation criteria may include:

- Revenue generated by the cell
- Distribution of VIP users
- Deployment role of the cell

b) Dynamic mode evaluation criteria

Dynamic mode evaluation criteria bring more opportunities to change a cell's importance during the operational phase. Generally, the frequency of a cell's importance update can be shortened explicitly (e.g. a few hours or days). The dynamic mode evaluation criteria are foreseen to be strongly correlated to the operational indicators of a cell. Some operational indicators which may be used to determine a cell's importance dynamically include:

- Operational status of a cell, such as energySaving state, cell outage state, or other cell states identified for the SON coordination purpose. For example, when a cell is in energySaving state, it should consume less management resources and then be regarded as unimportant in this sleeping phase. However, in another similar scenario, when the cell is in an outage status, the importance of the cell should be improved to get more management resources to detect the root cause of the outage.

The details of how do evaluation criteria work in the IRPManager or the IRPAgent are FFS.

7.3 Policy-based management

In a policy-based system, the operator defines groups of managed entities with operator-selected characteristics. The operator may set a policy describing how each group should be managed.

Policy-based management would reduce the amount of configuration data to be managed by the IRPManager. The IRPManager would only need to set the configuration data for each group.

The policy allocation should support a mechanism where operator may specify a set of Key Performance Indicators (KPIs) and their thresholds as criteria for allocating NE to a particular management group managed by a common policy. The mechanism may be implemented as a rule set or as a grouping policy. The NEs will be allocated to specific groups not only by the “importance” parameter manually configured by the operator, but also by evaluating the important operational indicators such as amount of carried traffic, number of served UEs, number of incoming and outgoing handovers, presence of VIP users, call failure rates, state of energy savings (ES) algorithm on the NE and neighbouring NEs, coverage area information, base station type, etc. The KPIs or operational indicators will be re-evaluated periodically and NEs may change their management group assignments accordingly.

7.4 Reduction of management data

7.4.1 Filtering

The quantity of management data may be reduced by filtering performance data, trace data and notifications carrying alarms and configuration data over Itf-N.

The 3GPP Performance Management IRP allows the IRP Manager to specify exactly which Measurement Families, Measurement Types or subcounters should be collected.

The 3GPP Trace IRP allows the IRPManager to specify exactly in which area scope shall trace data be collected.

The 3GPP Alarm IRP allows filtering of alarm lists, alarm counts and alarm-related notifications.

The 3GPP Notification IRP allows filtering of subscribed notifications.

7.4.2 Aggregation

The quantity of management data may be reduced by aggregating alarms and performance data.

Editor’s Note: Further details are FFS

7.4.3 Probabilistic management

A group of NEs with similar characteristics (e.g. deployed in the same area, similar priorities, etc...) in specific Use Cases can reduce the overall amount of alarms and performance data by applying probabilistic approach to decide which particular group member(s) shall report particular management information.

Editor’s Note: Further details are FFS

7.4.4 Reduction of PM data

The overall amount of PM data for a cell may be reduced by use of longer PM collection and reporting intervals.

The value of less frequently reported PM data for management and optimization decisions at the Network Management level may be increased by reporting the locally predicted performance measurement trends (e.g. rate of change, direction of change, prediction confidence level, etc...).

7.5 Self-configuration

As the number of managed nodes increases, it is not practical to plan and configure each node individually. As a long-term goal, it should be possible to have a node delivered directly from a factory to the site and the node should be automatically configured to begin operation within the network.

For this long-term goal to become a reality, the following issues must be solved:

- Only legitimate equipment should be connected to the operator's network.
- The operator's equipment cannot be moved to another operator's network.
- Newly-connected radio equipment must not degrade performance of neighbouring cells.

These issues should be investigated in a separate plug-and-play study because they have very little relevance for Itf-N. However, Itf-N may be used by the operator to check that the self-configuration process has been completed successfully. In particular, the Inventory Management IRP will be essential to allow verification that the newly-installed equipment has the correct hardware, software, and licenses.

7.6 Self-healing

In a large network, it is essential that faults should be resolved automatically if possible.

Nodes should be capable of restarting automatically in case of failure. In case of failure, the nodes should be able to fallback to a previous configuration or perform a factory reset.

The network should be tolerant of node failures. Existing 3GPP Itf-N features "Cell Outage Detection" and "Cell Outage Compensation" may be used.

7.7 Self-optimization

As the number of nodes to be managed will increase significantly by introducing large quantity of base station nodes, the optimization of the network should be done automatically as much as possible.

Network should be capable of optimizing automatically to improve capacity and/or coverage, and to optimize the overall network performance under the condition that the roles of some of the nodes could change over time.

Besides the traditional self-optimization features (HO parameter Optimization, Load Balancing Optimization, Capacity and Coverage Optimization, RACH Optimization and Inter Cell Interference Coordination), the management of enhanced Inter-Cell Interference Coordination (eICIC), which specifically considers HetNet interference scenarios, should be investigated in the scope of self-optimization with the aim of reduction of management.

8 Conclusions and recommendations

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2011-08					First creation of skeleton.	-.-.-	0.0.0
2011-08					Scope, some use case and requirements are introduced.	0.0.0	0.0.1
2011-10					Inclusion of agreed pCRs at SA5#79: S5-113204r1.	0.0.1	0.0.2
2012-02					Inclusion of agreed pCRs at SA5#81: S5-120193, S5-120194.	0.0.2	0.0.3
2012-04					Inclusion of agreed pCRs at SA5#82: S5-120609, S5-120743, S5-120746, S5-120750, S5-120751, S5-120788	0.0.3	0.0.4
2012-05					Inclusion of agreed pCRs at SA5#83: S5-121364, S5-121366.	0.0.4	0.0.5
2012-08					Inclusion of agreed pCR at SA5#84: S5-122179	0.0.5	0.0.6
2012-10					Inclusion of agreed pCR at SA5#85: S5-122550	0.0.6	0.0.7
2012-11					Inclusion of agreed pCRs at SA5#86: S5-123138, S5-123146, S5-123190	0.0.7	0.0.8
2013-02					Inclusion of agreed pCRs at SA5#87: S5-130329, S5-130330, S5-130331	0.0.8	0.0.9
2013-03	SA#59	SP-130143			MCC editorial cleanup, presented for information	0.0.9	1.0.0
2013-04					Inclusion of agreed pCRs at SA5#88: S5-130757, S5-130790	1.0.0	1.1.0
2013-06					Inclusion of agreed pCR at SA5#89S5-131070	1.1.0	1.2.0
2013-09					Inclusion of agreed pCR at SA5#90: S5-131423	1.2.0	1.3.0