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Technical Report

3rd Generation Partnership Project;
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Study on Operations, Administration and Maintenance (OAM) aspects of inter-Radio-Access-Technology (RAT) energy saving (Release 11)

Keywords
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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.
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Introduction

Every single unused Wh may save precious resources and prevent exceeding thresholds for irreversible climate change. It also will help to lower the cost of mobile telecommunication. Therefore any efficient effort to reduce the energy consumption of mobile networks is worthwhile. OAM can contribute to these efforts through solutions that can manage underused network resources by activating or deactivating them as necessary to fulfil the service levels required by mobile network users. This activation / reactivation is not restricted to single RATs, but different RATS can work together to find the optimal balance between energy consumption and service readiness.

Only LTE offers a possibility to directly exchange information between radio network elements (X2 interface). The other RATs in the scope of this study may not support this. Therefore OAM based methods are one possible solution for Inter-RAT Energy Saving.

1 Scope

General material - [2], [3] - and detailed material - [4], [5], [6] - on Energy Saving and/or its Management aspects have been created by 3GPP. The present document focuses on Inter-RAT aspects of Energy Saving, i.e. reducing the capabilities of one RAT to reduce its energy consumption while providing a back-up by another RAT. Concepts and scenarios described in [2], [3] and methods defined in [4], [5], [6] as well as additions to them are analysed to identify the most favourable management solutions in this context and their possible limitations.

The following RATs are considered in this study: GSM, UMTS; LTE, CDMA.

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 32.826: "Telecommunication management; Study on Energy Savings Management (ESM)".

[3] 3GPP TR 36.927: "Potential Solutions for energy saving for E-UTRAN".

[4] 3GPP TS 32.551: "Telecommunication management; Energy Saving Management (ESM) Concepts and requirements".

[5] 3GPP TS 32.522: "Telecommunication management; Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[6] 3GPP TS 32.762: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)".

[7] 3GPP TS 32.500: "Telecommunication management; Self-Organizing Networks (SON); Concepts and Requirements".

3 Abbreviations and Definitions

3.1 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] 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 [1].

ES	Energy Saving
ESM	Energy Saving Management
OAM	Operation, Administration, Maintenance
RAT	Radio Access Technology
Wh	Watt hour (unit for energy)

3.2 Definitions

In this document the following definitions are used:

The term "RAT 1" signifies the RAT which provides overlay/back-up coverage. This RAT is not taking energy saving measures, i.e. be always on.

The term "RAT 2" signifies the RAT which provides overlaid or hotspot coverage. This is the RAT where energy saving measures may take place.

4 Inter-RAT energy saving scenarios and use cases

4.1 Scenarios

4.1.1 Involved RATs and their combinations

The following RAT combinations are considered in this study:

Table 4.1.1-1 RAT combinations for Inter-RAT ESM

RAT 1	RAT 2
GSM (see Note)	UMTS
GSM	LTE
UMTS	LTE
CDMA2000 (see Note)	LTE

NOTE: This RAT1-RAT2 combination is currently not explicitly mentioned in TR 36.927. This does not exclude an OAM based solution.

Remark:
WLAN was intensively discussed in the study. Currently WLAN is not considered as RAT in the Inter-RAT Energy Saving. One reason is that managed HO to/from WiFI from/to other RATs is not available in Rel-11.

4.2 OAM Architectures for Inter-RAT ESM

4.2.1 Introduction

Considering inter-RAT scenarios and to align with architecture definitions in TS 32.551[4], the possible architectures for inter-RAT ESM could be:

Centralized ES: ES solution where ES algorithm is executed in the OAM system. Centralized ES has two variants:

- **NM-Centralized ES:** ES solution where ES algorithm is executed at the Network Management level.
- **EM-Centralized ES:** ES solution where ES algorithm is executed at the Element Management level.

Distributed ES: ES solution where ES algorithm is executed at the Network Element level.

The following figures illustrate how the architectures are applied in inter-RAT energy saving scenarios. In the figures, UMTS represents RAT 1 and LTE represents RAT 2 as an example.

4.2.2 NM-centralized ES architecture

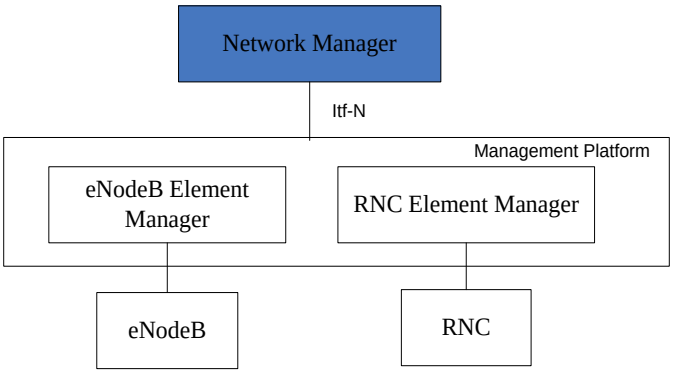

Figure 4.2-1 NM-centralized ES architecture

As shown in figure 4.2-1, the inter-RAT ES algorithm is located in the Network Manager (the blue block). The Network Manager collects information from both the Element Manager of eNodeB (for LTE) and the Element Manager of RNC (for UMTS) as the input of its algorithm for trigger mechanism of energy saving procedures (energy saving activation or energy saving deactivation). The information mainly includes statistical PM information, such as cell load of each involved cell in inter-RAT energy saving. The Network Manager directly initiates energy saving procedures over Itf-N. There's no signalling interaction between two inter-RAT network elements, such as eNB and RNC.

4.2.3 EM-centralized ES architecture

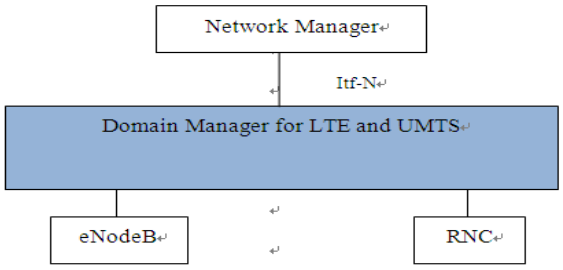

Figure 4.2-2 EM-centralized ES architecture, two-RAT-capable Domain Manager

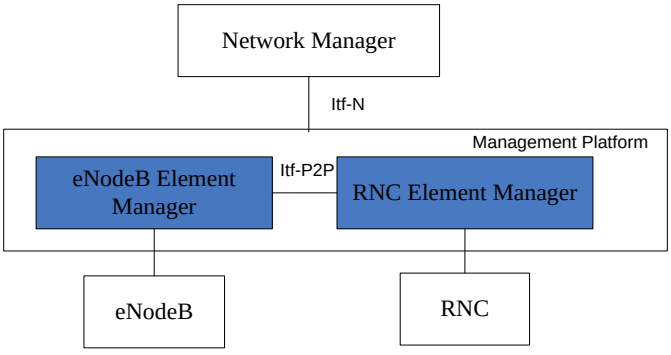

Figure 4.2-3 EM-centralized ES architecture using Itf-P2P for information exchange between Element Managers

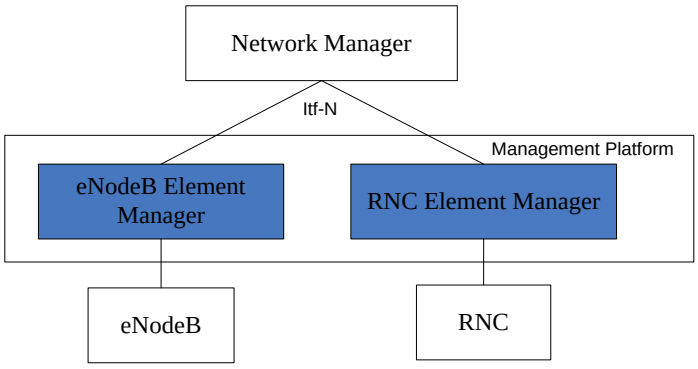

Figure 4.2-4 EM-centralized ES architecture using Itf-N for information exchange between Element Managers

As shown in figure 4.2-2, 4.2-3, 4.2-4, the inter-RAT ES algorithm is located in the layer of Element or Domain Manager(s) (the blue block). The Network Manager configures ES policies as one source of the input of Element/Domain Manager's algorithm, such as load thresholds for energy saving activation, load threshold for energy saving deactivation. On the other hand, Element/Domain Manager collects information from the underlying network elements in its domain as another source of the input to its algorithm for trigger mechanism of energy saving procedures. The information may include statistical PM information or cell load. The Element/Domain Manager directly initiates energy saving procedures to the underlying network elements. There's no signalling interaction between two inter-RAT network elements, such as eNB and RNC.

There are three options for EM-centralized ES architecture to manage inter-RAT energy saving:

Option 1: As shown in figure 4.2-2, one Domain Manager is capable of managing network elements of two RATs.

Option 2: As shown in figure 4.2-3, Itf-P2P may be enhanced to exchange information between Element Managers of the two RATs.

Option 3: As shown in figure 4.2-4, Element Managers of the two RATs exchange information via Network Manager (over Itf-N).

4.2.4 Distributed ES architecture

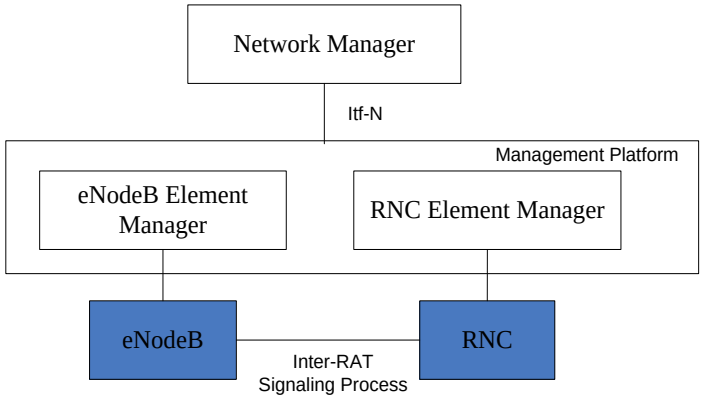

Figure 4.2-5 Distributed ES architecture

As shown in figure 4.2-5, the inter-RAT ES algorithm is located in the network elements from different RATs (the blue block), such as eNodeB for LTE and RNC for UMTS. The Network Manager configures ES policies (via the Element Manager) as one source of the input of the NE's algorithm, such as load thresholds for energy saving activation, load threshold for energy saving deactivation. On the other hand, the NEs from different RATs monitor their own cell load and exchange load status to each other via inter-RAT signalling prrocess, such as RIM (RAN Information Management) based procedure. The monitored load information is used by the NE as another source of the input to its algorithm for trigger mechanism of energy saving measures.Distributed architecture aligns with signalling based solution in TR 36.927 [3].

Which out of these are applicable for Inter-RAT energy saving is FFS.

4.3 Use cases

4.3.1 Use case 1 Overlapping of non-collocated cells of different RATs with significantly different coverage areas

RAT1 cell provides a basic coverage while RAT 2 cell provides additional capacity and/or different services/service quality at specific locations ("hotspots"). The coverage area of RAT 2 cell is usually significantly smaller than the coverage area of RAT 1 cell. RAT 1 cell fully covers RAT 2 cell. The locations of the antennas of RAT 1 and 2 are not the same.

The RAT 2 can consist of single cells – see figure 4.3.1-1 – and/or a group of cells – see figure 4.3.1-2.

A RAT 2 cell may be overlaid by one RAT 1 cell – like the left part in figure 4.3.1-1 - or by multiple RAT 1 cells – like the middle part in figure 4.3.1-1.

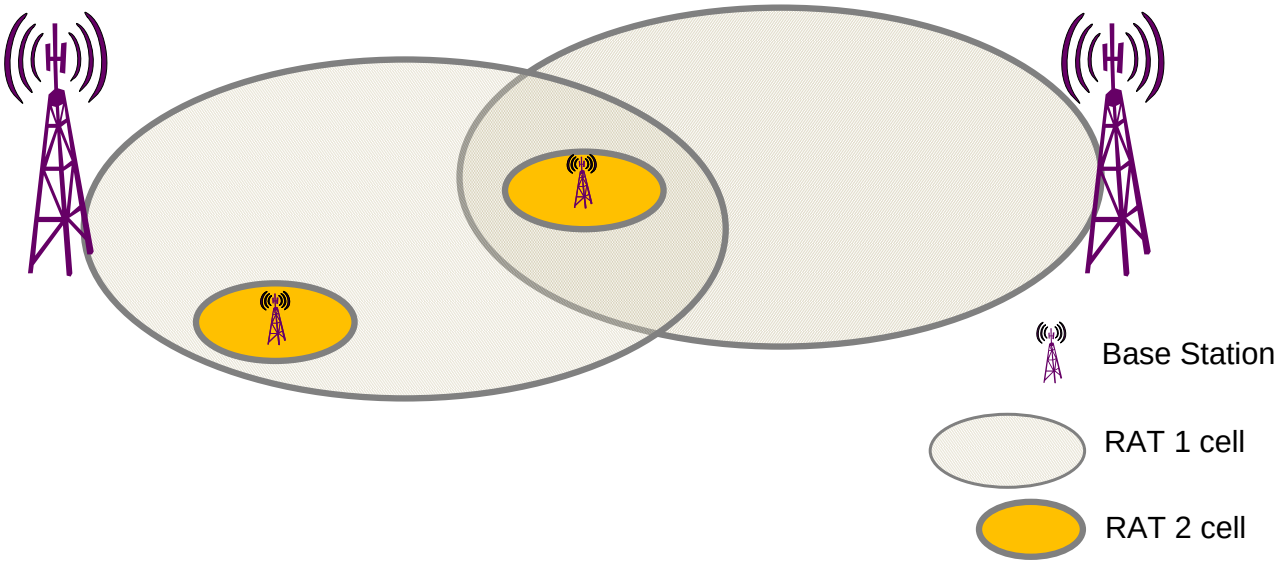

Figure 4.3.1-1

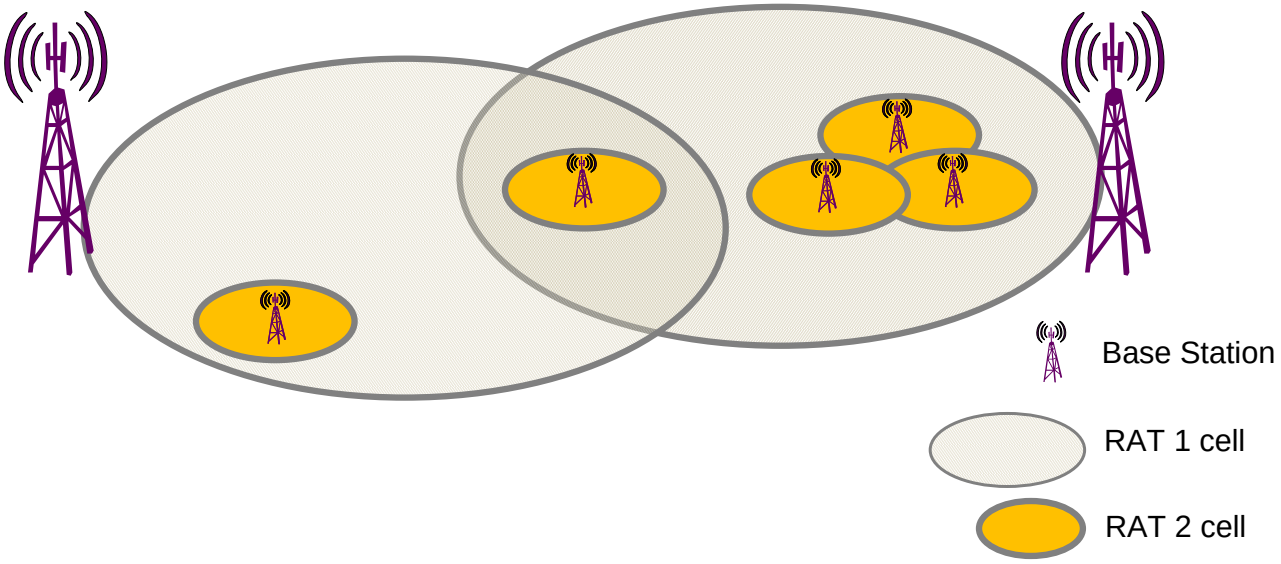

Figure 4.3.1-2

In case RAT2 is LTE and the cells can overlap, both the LTE Energy Saving function and the inter-RAT Energy Saving function can be executed. Figures 4.3.1-4, 4.3.1-5 show the two possible steps:

Step 1) LTE Energy Saving is activated. In this case some LTE cells are turned off and another LTE cell enters into compensation mode (see 32.551). The Inter-RAT energy saving is not enforced. The LTE in compensation mode guarantees LTE coverage.

Step 2) Inter-RAT Energy Saving is activated. In this case one or more LTE cells are turned off and the RAT1 cell guarantees radio coverage. The LTE coverage is not guaranteed in this case.

These two steps can be done individually or consecutively where step 1 precedes step 2.

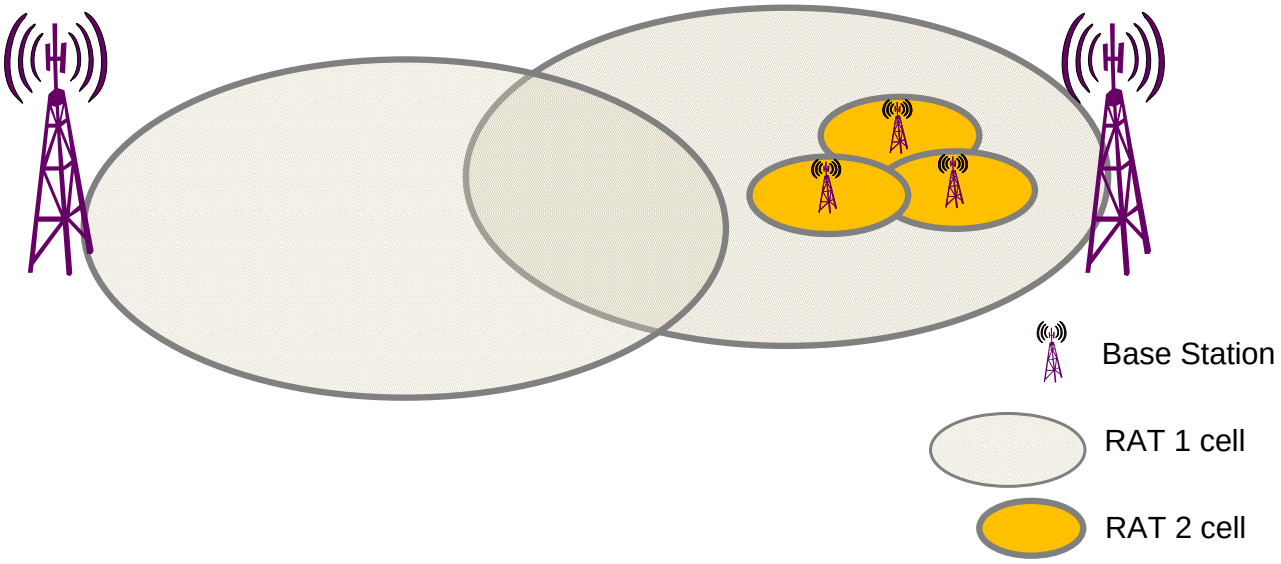

Figure 4.3.1-3 No ES

Figure 4.3.1-3 shows the starting situation.

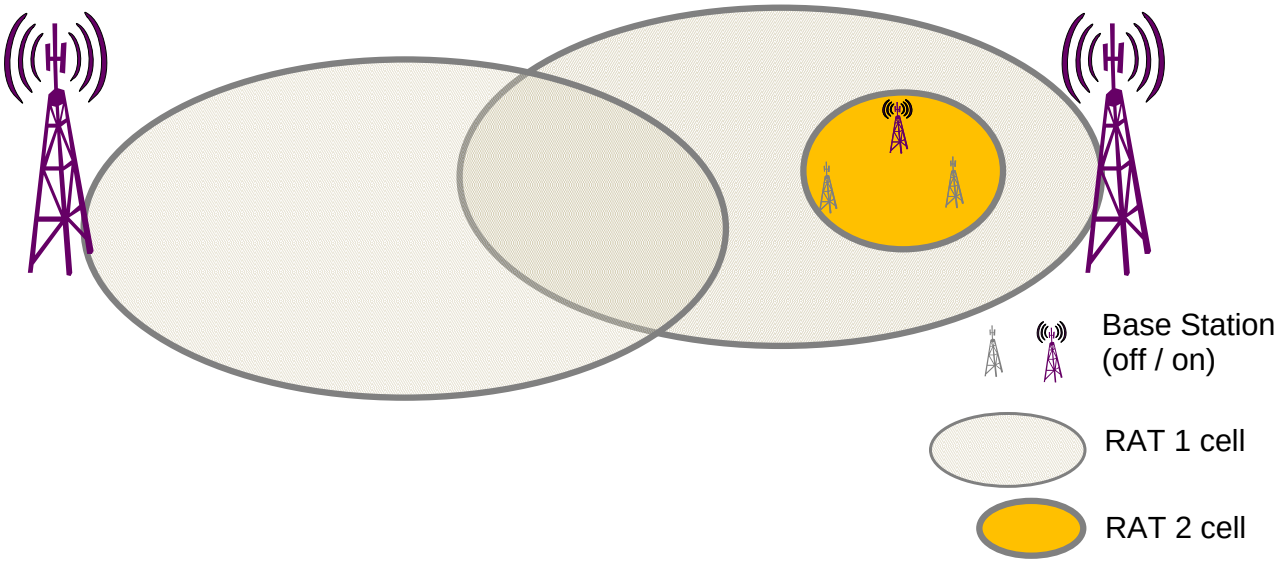

Figure 4.3.1-4 LTE (Intra-RAT2) ES

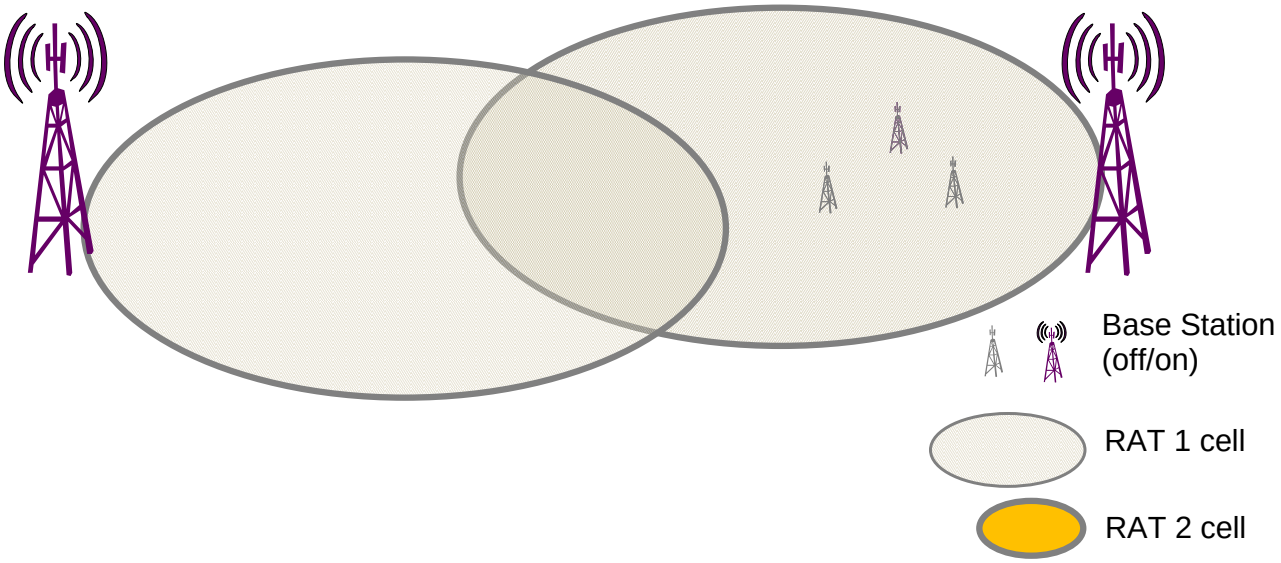

Figure 4.3.1-5 Inter-RAT ES- all RAT2 cells off

Since energy saving can take place at inter-RAT level or at LTE level, it is necessary to define which energy saving solution will be executed. It is recommended that the execution prioritization between Intra-RAT and inter-RAT ES is controlled by an operator-defined policy.

The policy can e.g. be defined by suitable load thresholds Thr1 and Thr2 as follows:

1. When intra-RAT ES is prioritized, if RAT2 load in a cell drops below Thr1 the RAT2 cell is sent to dormant state and another RAT2 cell(s) is(are) compensating , If the RAT2 load decreases further below Thr2 (< Thr1) also the compensating RAT2 cell(s) is(are) turned to dormant.

2. When inter-RAT ES is prioritized, a RAT2 cell is directly sent to dormant when threshold Thr2 (>Thr1 or Thr1 is disabled) is crossed. No compensation from RAT2 cells is triggered.

4.3.2 Use case 2 Overlapping of collocated cells of different RATs with similar coverage area

In this use case two RATs provide approximately the same coverage area. The different RATs may be used to provide different services or service qualities. The locations of the antennas of RAT 1 and 2 are almost the same, e.g. are mounted on the same tower.

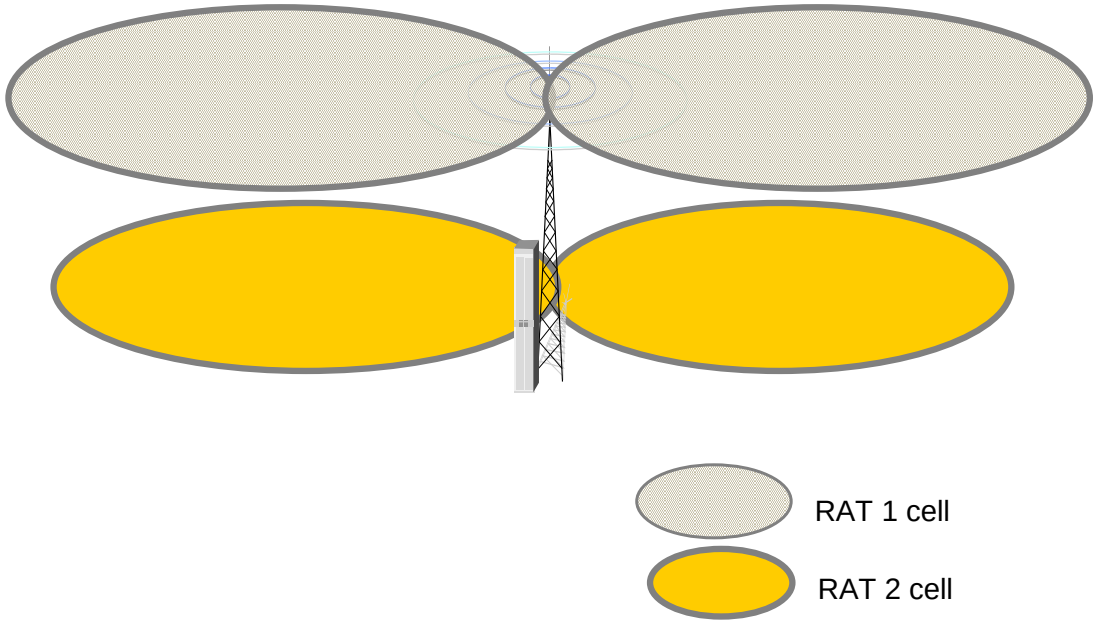

Figure 4.3.2-1

In case RAT1 is LTE and the cells can overlap, both the LTE Energy Saving function and the inter-RAT Energy Saving function can be executed. Figure 4.3.2-2 shows the two alternative mechanisms:

1) LTE Energy Saving is activated. In this case one LTE cells is turned off and another LTE cell enters into compensation mode (see 32.551). The Inter-RAT energy saving is not enforced. The LTE in compensation mode guarantees LTE coverage.

2) Intra-RAT Energy Saving is activated. In this case one LTE cell is turned off and the RAT2 cell guarantees radio coverage. The LTE Energy saving is not enforced. The LTE coverage is not guaranteed in this case.

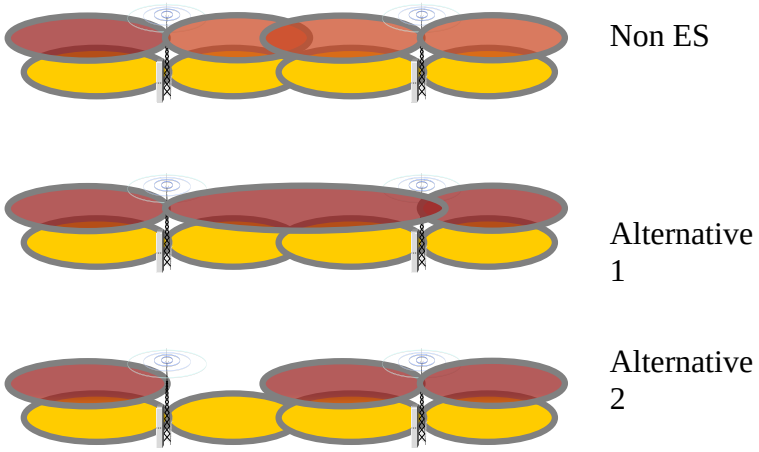

Figure 4.3.2-2

Since energy saving can take place at inter-RAT level or at LTE level, it is necessary to define which energy saving solution will be executed. It is recommended that the execution prioritization between Intra-RAT and inter-RAT ES is controlled by an operator-defined policy.

The policy can e.g. be defined by suitable load thresholds:

When intra-RAT ES is prioritized, at one threshold value the relevant RAT2 cell is sent to dormant state and another one is compensating, and at a lower threshold value also the compensating cell is turned to dormant or reconfigured to stop compensating.

When inter-RAT ES is prioritized, the RAT2 cell is directly sent to dormant without another RAT2 cell having been compensating.

4.3.3 Use case 3 Combination of collocated RAT1-RAT2 cells with non-collocated RAT2 cells

In this use case two RATs provide approximately the same coverage area, but in RAT2 additional cells provide additional capacity and/or different services/service quality at specific locations ("hotspots").

The RAT 2 hotspots can consist of single cells and/or a group of cells.

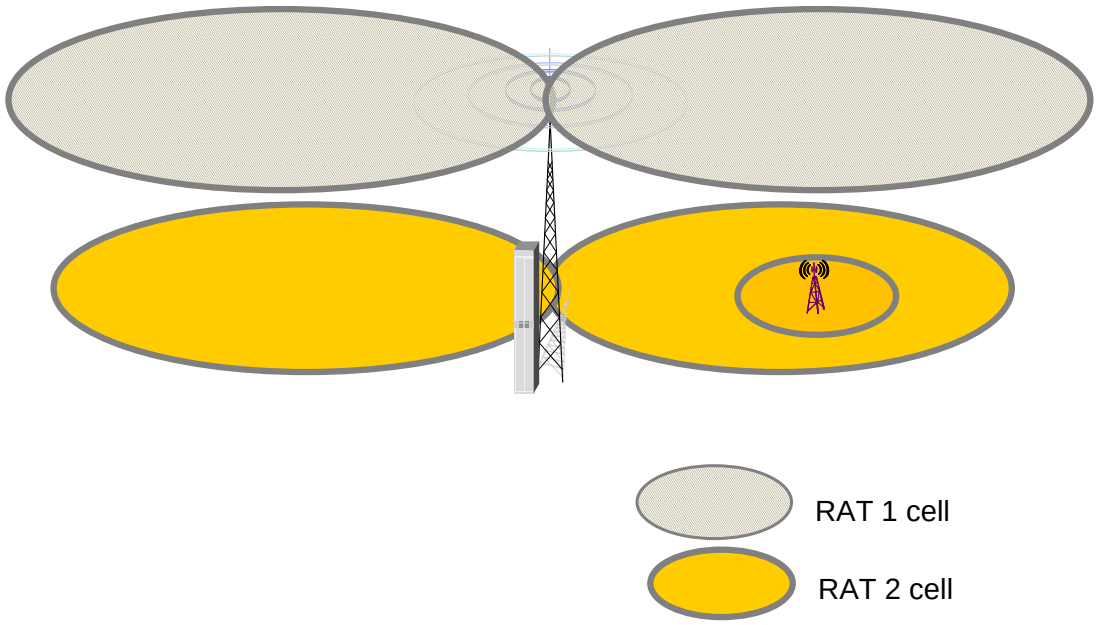

Figure 4.3.3-1

In case RAT2 is LTE and the cells can overlap, both the LTE Energy Saving function and the inter-RAT Energy Saving function can be executed. Figures 4.3.3-2, 4.3.3-3 show the two alternative mechanisms:

1) LTE Energy Saving is activated. In this case the hotspot LTE cells are turned off, coverage LTE cell compensates (usually without reconfiguration) and guarantees LTE coverage. The Inter-RAT energy saving is not enforced.

2) Inter-RAT Energy Saving is activated. In this case all LTE cells are turned off and the RAT1 cell guarantees radio coverage. The LTE Energy saving is not enforced. The LTE coverage is not guaranteed in this case.

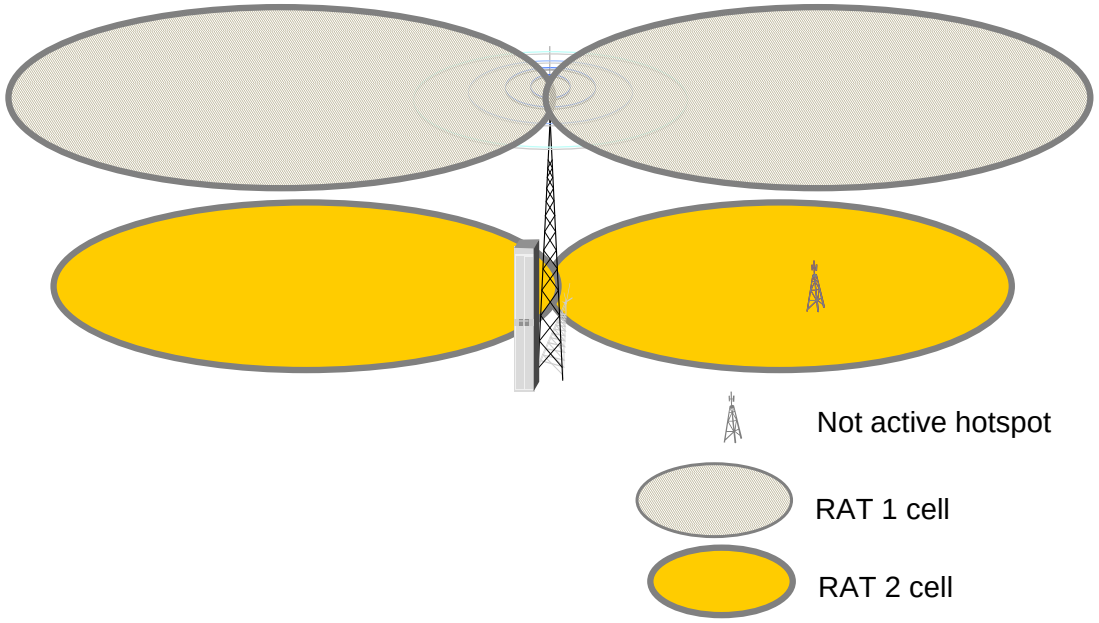

Figure 4.3.3-2 Intra-RAT2 ES

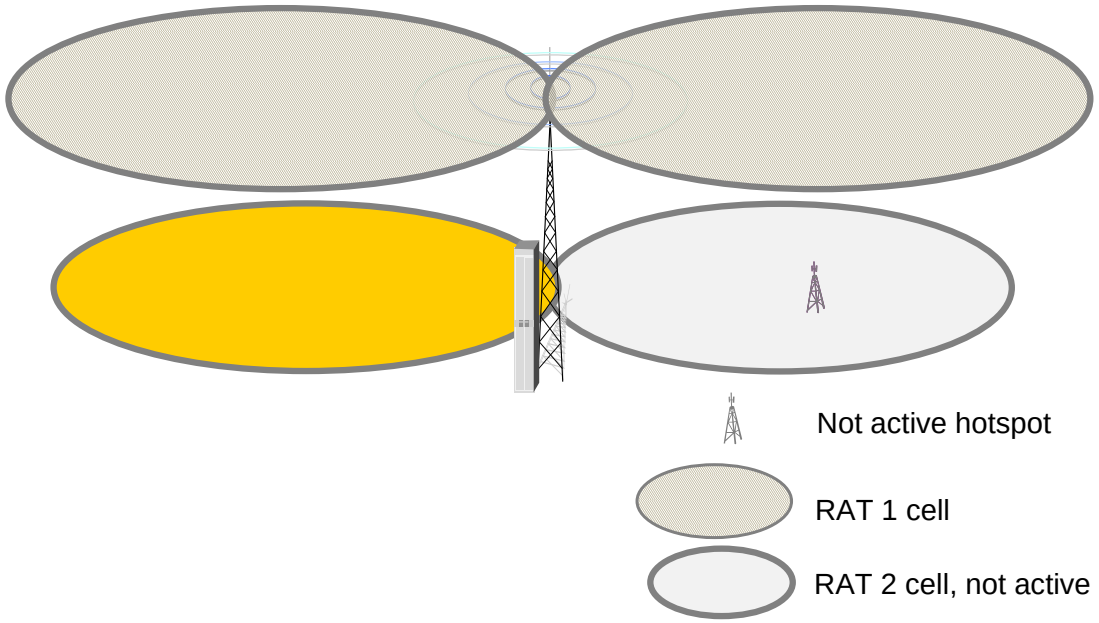

Figure 4.3.3-3 Inter-RAT ES

Remark: The situation shown in figure 4.3.3-3 can also be reached after the situation shown in figure 4.3.3-2 had been present.

Since energy saving can take place at inter-RAT level or at LTE level, it is necessary to define which energy saving solution will be executed. It is recommended that the execution prioritization between Intra-RAT and inter-RAT ES is controlled by an operator-defined policy.

The policy can e.g. be defined by suitable load thresholds, which compared to current 32.522 need an extension to distinguish between a threshold which sends a cell to dormant state AND brings (an)other cell(s) to perform intra-RAT ES compensation and a threshold which only sends a cell to dormant without triggering compensation.

When intra-RAT ES is prioritized, at one threshold value a hotspot RAT2 cell is sent to dormant state and another one RAT2 cell is compensating, and at a lower threshold value also the RAT2 coverage cell is turned to dormant.

When inter-RAT ES is prioritized, all RAT2 cells are directly sent to dormant when a threshold is crossed.

4.3.4 Ruled out use case: Capacity limited network

TS 32.551 [4] has a use case capacity limited network, where the coverage of energy saving cells is taken by neighbour cells whose coverage area before had been limited by signal strength of the formerly active cell. This use case does not apply for Inter-RAT ESM, because the different frequencies used do not result in such an almost automatic coverage mechanism.

4.3.5 Constraints for use cases

The following considerations must be taken into account:

If a UE does not support RAT 1, energy saving measures of RAT 2 may result in a loss of service for that UE.

If a UE is located in an area, where RAT 2 cell provides coverage, but the signal of RAT 1 cell is very weak, energy saving measures of RAT 2 cell may result in a loss of service for that UE.

The difference in service quality between RAT 1 and RAT 2 may be such that the customer experience during energy saving may be degraded.

5 OAM based Inter-RAT energy saving concepts

5.1 Energy Saving States

The following criteria are generally used to evaluate the states of energy saving:

Criterion 1: Degree of energy saving effect

Criterion 2: Controllability from the network

Criterion 3: Service availability

The following energy saving states of a cell or a network element defined in 3GPP TS 32.551 [4] are identified to be re-used for Inter-RAT ESM:

Conceptually, a cell or a network element may be on one of these two states with respect to energy saving:

- notEnergySaving state
- energySaving state

Table 5.1-1 shows the above criteria applied to these states.

Based on the above energy saving states, a full energy saving solution includes two elementary procedures:

- Energy saving activation (change from notEnergySaving to energySaving state)
- Energy saving deactivation (change from energySaving to notEnergySaving state)

Table 5.1-1 Criteria for energy saving state

Criterion	notEnergySaving state	energySaving state
Degree of energy saving effect	The cell in notEnergySaving state will not consider energy saving as the first priority, but it is left to the vendor implementation how to minimize energy consumption while providing service availability. This minimization may include switching off hardware elements.	The energySaving state represents the maximum energy saving effect on the cell level. Hardware components shall be switched off for energy saving purpose as far as possible.Which hardware components are switched off is an issue specific to NE implementation.
Controllability from the network	The cell in notEnergySaving state is under control of the network. Therefore, network interface as X2/S1 and OAM connection shall be enabled when the cell is in notEnergySaving state.	The cell in energySaving shall support the capability to be switched on again by the network, such as by its neighboring cells (eNBs) or the OAM system. Therefore, a network interface such as X2/S1 or the OAM connection shall be enabled when the cell is in energySaving state.
Service availability	The cell in notEnergySaving state should provide complete service to UEs in the coverage area of a cell. From the view of such an UE, the cell in notEnergySaving state is visible when the UE scans all RF channels according to its capabilities.	The cell in energySaving state does not provide any service to UEs. From the view of an UE, a cell in energySaving state is not visible..

When a cell is in energySaving state it may be needed that neighboring cells pick up the load. However a cell in energySaving state cannot cause coverage holes or create undue load on the surrounding cells. All traffic on that cell is expected to be drained to other overlaid/umbrella cells before any cells moves to energySaving state.

A cell in energySaving state is not considered a cell outage or a fault condition. No alarms should be raised to the IRPManager for any condition that is a consequence of a NE moving into energySaving state.

These energy saving states are valid for all architectures.

The following energy saving state of a cell or a network element defined in 32.551 is identified to be not re-used for Inter-RAT ESM:

"compensatingForEnergySaving".

Reason: This state is only valid for capacity-limited use cases, and therefore this concept is not considered in this study.

The introduction of additional energy saving levels, e.g. a stand-by mode where the radio part of an eNB keeps active, is FFS.

5.2 Inter-RAT ESM thresholds

For Intra-RAT ESM 3GPP TS 32.522 [5] defines in IOC ESPolicies thresholds to be taken into account for activating and deactivating energy saving in a network element. ESPolicies instances can be contained under IOC instances Subnetwork or ENBFunction or EUtranGenericCell.

This modelling needs to be adapted for Inter-RAT ESM:

- Thresholds need to be defined for the different RATs differently.
- To prioritize Inter-RAT ESM thresholds need to be defined to send a RAT2 cell to compensating mode.

5.3 Concept 1: Statistical ESM

5.3.1 General description

To prepare energy saving activities load measurements are done for a significant time duration (typically a few weeks) in a BTS/eNB and cell specific way. Also other information like traffic measurements can be gathered as e.g. typical terminal capabilities (support of RATs) in a cell.

Remark: Which other measurements are used here is FFS.

These measurements deliver statistical data about the typical load situation during the day or the week, the presence of users and other data relevant for an energy saving decision.

Based on the analysis of the data time periods per BTS/eNB and per cell are identified when energy saving measures are possible. These time periods are used to activate/deactivate energy saving measures.

Further measurements are done to supervise the effects of the energy saving measures. This includes e.g. measurements about the load situation in RAT1.

Ahead of schedule reactivation of energy saving network elements may be needed by a network operator. It can be triggered when significant deviations from the statistics appear, e.g. based on load indicators of RAT1.

Statistical ESM applies for NM centralized ESM architecture.

5.3.2 Operator Control of Statistical ESM

In Statistical ESM the network operator

- activates via OAM the energy saving of a network element (according to the determined schedule)
- configures via OAM trigger points (e.g. load threshold crossing) when it wants to be notified
- deactivates via OAM the energy saving of a network element. This is done at the – planned or ahead of schedule - end of an interval suitable for energy saving.

5.4 Concept 2 Delegated ESM

5.4.1 General description

In this energy saving concept the decisions about energy saving measures are taken by ESM functionality below Itf-N. The network operator provides the basic information needed for the ESM functionality to decide about energy saving measures.

This ESM concept applies to the EM-centralized OAM and distributed architecture for Inter-RAT ESM.

5.4.2 Operator control of Delegated ESM

In Delegated ESM the network operator can set policies for:

- Time period, during which energy saving is allowed
- Which cells of different RATs are to be considered when a ES decision is made

Load thresholds to be considered for energy saving decisions

- Which of the RATs present should be “ramped down” first, which second …
- If the preference of the network operator is energy efficiency or service availability and/or quality of service or a compromise between these aspects.

Based on this information, potentially further information – e.g. the operational status of the candidate cell to take over - and the load in the network the ESM function controls the energy saving measures in the network elements. The network operator is informed about configuration changes which are triggered by the ESM function.

5.5 Concept 3: Load based trigger determination

Statistical ESM concept uses the statistics of traffic load (load measurements) in BTS/NB/eNB over a period of time to determine the time interval of energy saving activation or deactivation, based on certain load thresholds. Delegated ESM uses load threshold to decide on ESM actions.

Considering the service/QoS differentiation between RAT 1 (e.g. GSM, UMTS) and RAT 2 (e.g. LTE), when activating energy saving measures, the trigger mechanism of load threshold is enhanced by additional information to determine whether the traffic load in RAT 2 cell can be carried in the backup RAT 1 cell.

RAT 2 cell can enter the energy saving state only if it is determined that the service impact is acceptable to RAT 2 subscribers according to the policy from the operator.

The following shows an example of inter-RAT energy saving activation.

- RAT 2 cell could perform the energy saving measures at the time determined by the statistical load measurements or by crossing t he relevant threshold.
- RAT 2 cell uses additional information to determine the impact to UE services. For example:
    - The number of UEs attached to such RAT 2 cell (with RRC state = RRC_CONNECTED), to determine if RAT 2 cell can enter the energy saving state according to the operator policy. If the number of UEs attached to the RAT 2 cell is lower than the one specified in operator's policy, it means that the service impact is acceptable. Therefore RAT 2 cell can start the energy saving measures and enter energySaving state.
    - The ISR (Idle mode Signalling Reduction) state of idle mode UEs that are camped on the RAT 2 cell. If the ISR is activated on the UE, it means that the UE is registered with both MME and SGSN. When the RAT 2 cell is switched off, the UE is still registered at the GERAN/UTRAN cell that continues to provide UE services. If the ISR is deactivated on an UE, it means that the idle mode UE is registered with MME in E-UTRAN only. When the RAT 2 cell is switched off, the idle mode UE is in the EMM_DEREGISTERED state, and can't no longer receive services. Therefore, the ISR activation / deactivation state of the UE can be used as the measurement to determine if the UE service impact is acceptable or not if the RAT 2 cell is switched off. If the number of UEs which are camping on the RAT 2 and have ISR deactivated, is lower than the one specified in operator's policy, it means that the service impact is acceptable. Therefore RAT 2 cell can start the energy saving measures and enter energySaving state.

      Note the ISR state of idle mode UEs is based on the following assumption for the UE:

      a) During the off-peak hours, most UE are in the idle mode.

      b) During the off-peak hours, most UE are stationary, and should be camped on the same eNB as the one when they enter the idle mode last time.

      c) The UEs are camped on both E-UTRAN and GERAN/UTRAN, and should be in the EMM_REGISTERED state, so it can be paged for downlink messages from E-UTRAN and GERAN/UTRAN.

      d) ISR is supported.

    - The impact of energy saving activation on service quality may be considered before the energy saving activation is performed. If and by which method this can be achieved is FFS.

When deactivating energy saving measures, it's also necessary to identify whether the increased load in RAT 1 cell can potentially be transferred to RAT 2 cell. A check should be done, if the UEs of RAT 1 cell which are candidates for handover to RAT 2 cell are RAT 2 capable. If so, RAN 1 cell should wake up the energySaving RAT 2 cell as soon as possible.

Which information could be used for this load based trigger determination is FFS.

Which information is suitable for operator policies in this context is FFS

5.6 Commonalities of concepts

The concept 3 (load based trigger determination) can be applied as an addition to concept 2 (Delegated ESM).

6 OAM based Inter-RAT energy saving requirements

6.1 General requirements

The following requirements apply to inter-RAT energy saving use case.

REQ-32.834-CON-01

The operator shall be able to monitor to what extent the network and the user service quality of RAT 2 are affected by inter-RAT energy saving function.

REQ-32.834-CON-02

When a RAT 2 NE is in energySaving state, it shall not be considered as a fault, and no alarm shall be raised to the operator for any condition that is a consequence of an energy saving RAT 2 NE.

REQ-32.834-CON-03

A RAT 2 cell or a network element in energySaving state is a planned condition and should not be considered as an outage.

REQ-32.834-CON-04

The operator shall be able to query which cells within RAT 2 are in energySaving state.

REQ-32.834-CON-05

The operator shall be notified when a RAT 2 cell fails to re-start as a result of going out of energySaving state.

REQ-32.834-CON-06

A RAT 2 cell must not go into energySaving state until emergency calls or Wireless Priority Service calls in the cell are completed. Forcing handovers of such calls because of inter-RAT ES shall be avoided.

REQ-32.834-CON-07

Inter-RAT ESM shall not prevent the fulfillment of emergency service requirements (e.g. E911) and Wireless Priority Services requirements.

6.2 Requirements for Concept 1 (Statistical ESM)

REQ-32.834-CON-C1-01

The operator shall be able to initiate energy saving activation/deactivation on one or multiple RAT 2 cells or network elements in the network.

REQ-32.834-CON-C1-02:

The IRPAgent shall inform the IRPManager when the actual traffic deviates from a configured range.

Note: the actual definition of traffic and its range is for further study.

6.3 Requirements for Concept 2 (Delegated ESM)

REQ-32.834-CON-C2-01

The IRPAgent should support a capability allowing the the IRPManager to configure one or more related RAT1 cells as the candidate cell(s) to take over the coverage when the RAT2 cell is performing energy saving.

REQ-32.834-CON-C2-02:

The IRPAgent should support a capability allowing the IRPManager to configure the time period during which inter-RAT energy saving is allowed.

REQ-32.834-CON-C2-03:

The IRPAgent should support a capability allowing the IRPManager to configure a traffic threshold of RAT2 and a time duration: If the traffic in the RAT2 cell is below this threshold longer than this time duration, then the RAT2 cell is allowed to activate energy saving.

REQ-32.834-CON-C2-04:

The IRPAgent should support a capability allowing the IRPManager to configure a traffic threshold and a time duration: If the traffic in the back-up RAT1 cell(s) is above this threshold longer than this time, then the energy saving RAT2 cell is allowed to deactivate energy saving.

REQ-32.834-CON-C2-05

If the IRPAgent has no direct access to outage information about RAT1 cells, then the IRPManager should be able to indicate cell outage of a RAT 1 cell that is a candidate cell that can take over the coverage for RAT 2 cell.

REQ-32.834-CON-C2-06

The IRPManager shall be able to define the outage of which RAT1 cells shall end and prohibit energy saving activation of which RAT2 cells.

REQ-32.834-CON-C2-07

The operator shall be able to enable and disable inter-RAT energy saving for a selected part of the network.

REQ-32.834-CON- C2-08

The operator shall be able to define a list of cells to prevent them from going into energySaving state.

REQ-32.834-CON- C2-09

The operator shall be notified when a RAT 2 cell goes into or out of energySaving state.

REQ-32.834-CON-C2-10:

The IRPAgent shall support a capability for the IRPManager to set a traffic threshold whose crossing triggers energy saving activation in one or several RAT2 cell(s) and compensation configuration of one or more other RAT2 cell(s).

6.4 Requirements for Concept 3

REQ-32.834-CON-C3-01

The IRPAgent should support a capability allowing the IRPManager to configure thresholds (e.g. the number of UEs actively connected to RAT 2 cell) which reflect the acceptable service impact for RAT 2 cell.

Note: Other thresholds which reflect the acceptable service impact for RAT 2 cell are FFS.

7 Candidate solutions

7.1 General description

7.1.1 Re-use of E-UTRAN ESM solution for Inter-RAT ESM

7.1.1.1 Overview of E-UTRAN ESM solution

According to TS 32.103, E-UTRAN Energy Saving Management is implemented in the following IRPs

- PM IRP (32.41x)
- File Transfer IRP (for PM data upload) (32.34x)

- Basic CM IRP (32.60x) or Bulk CM IRP (32.61x)
- Kernel CM IRP (32.66x)
- Notification IRP (32.30x)
- SON Policy NRM IRP (32.52x)
- Generic NRM IRP (32.62x)
- E-UTRAN NRM IRP (32.76x)
- E-UTRAN Performance Measurements (32.425)

7.1.1.2 Analysis of impacts to IRPs

The following clauses analyze how E-UTRAN Energy Saving Management is implemented in each IRP, and how each IRP may be impacted by Inter-RAT Energy Saving Management.

7.1.1.2.1 SON Policy NRM IRP

The SON Policy NRM IRP is used by E-UTRAN ESM to enable/disable ESM in a distributed ES architecture.

The SON Policy NRM IRP is used by E-UTRAN ESM to define ESM load thresholds in a distributed ES architecture or in an EM-centralized ES architecture.

This IRP was written for use with E-UTRAN SON functions, but is generic enough that it is valid for all Radio Access Technologies. No special E-UTRAN features are used by E-UTRAN ESM.

Conclusion: This IRP may be re-used for Inter-RAT ESM.

7.1.1.2.2 E-UTRAN NRM IRP

The E-UTRAN NRM IRP is used by E-UTRAN ESM to support the following

- Desired Energy Saving state (for centralized architecture only)
- Actual Energy Saving state
- ES Coverage relations (only from E-UTRAN cell to E-UTRAN cell)

This IRP is only valid for E-UTRAN. Only ES Coverage relations between E-UTRAN cells are supported.

These attributes are only needed for a cell which will enter Energy Saving state, this means that they are only valid for RAT2.

Conclusions:

The E-UTRAN NRM IRP must be improved to allow Inter-RAT ES Coverage relations.

The ESM modelling in the E-UTRAN NRM IRP is also valid for UTRAN ESM, and therefore the UTRAN NRM IRP should model ESM in a similar style.

The ESM modelling in the E-UTRAN NRM IRP is not valid for GERAN ESM, because GERAN will not perform the role of RAT2.

Inter-RAT ES Coverage relations may be easily modelled as new `isESCoveredBy` attributes on the Inter-RAT relations.

7.1.1.2.3 E-UTRAN Performance Measurements

E-UTRAN Performance Measurements contains Energy Saving indications for RRC failure and cell unavailability. This allows Energy Saving to be counted as a planned event, not a failure case.

These indications are only needed for a cell which will enter Energy Saving state, this means that they are only valid for RAT2.

Conclusions:

The special ES indications are also valid for UTRAN ESM, and therefore similar indicators should be added to the UTRAN Performance Measurements.

The special ES indications are not valid for GERAN ESM, because GERAN will not perform the role of RAT2.

7.1.1.2.4 List of IRPs without impact

The following IRPs are used by E-UTRAN ESM but no special E-UTRAN features are used by E-UTRAN ESM.

- Performance Management IRP
- File Transfer IRP
- Basic CM IRP
- Bulk CM IRP
- Kernel CM IRP
- Notification IRP
- Generic NRM IRP

These IRPs are valid for all Radio Access Technologies.

Conclusion: These IRPs may be re-used for Inter-RAT ESM.

7.1.1.3 Conclusion

The current solution for E-UTRAN Energy Saving Management can easily be extended to support Inter-RAT Energy Saving Management. The necessary changes are as follows.

3GPP IRP	Changes to support Inter-RAT ESM
SON IRP	Add support for modelling of Inter-RAT ESM thresholds Time period during which Energy Saving is allowed
E-UTRAN NRM IRP	Add `isESCoveredBy` attributes to the Inter-RAT relations
UTRAN NRM IRP	Add support for modelling of Desired Energy Saving state Actual Energy Saving state Inter-RAT ES Coverage relations (from UTRAN cell to GERAN cell)
UTRAN Performance Measurements	Add Energy Saving indications for RRC failure and cell unavailability

7.1.1.4 Other issues

It would be very easy to add UTRAN-UTRAN ESM by adding a single `isESCoveredBy` attribute to the UTRAN-UTRAN relation. However, this is outside the scope of the current study.

7.1.2 Variant of re-use of E-UTRAN ESM solution for Inter-RAT ESM

7.1.2.1 Overview of E-UTRAN ESM solution

This is a solution which is very similar to the one described in clause 7.1. Therefore only the clauses with differences to sub-clauses of 7.1.2 are outlined in this following clause 7.2.2 .

7.1.2.2 Analysis of impacts to IRPs

7.1.2.2.1 SON Policy NRM IRP

This IRP may be re-used for Inter-RAT ESM with the following addition:

An object class to describe which cells of different RATs belong to a energy saving group, i.e. which cells of a RAT 2 provide overlay or backup up coverage for which cells of a RAT 1.

7.1.2.2.2 E-UTRAN NRM IRP

See 7.1.2.2 with the exception that the ES coverag relation is not modelled in this NRM IRP.

7.1.2.3 Conclusion

The current solution for E-UTRAN Energy Saving Management can easily be extended to support Inter-RAT Energy Saving Management. The changes needed are

3GPP IRP	**Changes to support Inter-RAT ESM**
SON IRP	Add support for modelling of Inter-RAT ESM thresholds **Inter-RAT ES cell groups** Time period during which Energy Saving is allowed
E-UTRAN NRM IRP	**-**
UTRAN NRM IRP	Add support for modelling of Desired Energy Saving state Actual Energy Saving state **-**
UTRAN Performance Measurements	Add Energy Saving indications for RRC failure and cell unavailability

Note: **Bold font** indicates difference to conclusion in 7.2.2 , a bold dash "-" a change neede in 7.2.2, but not needed in this solution.

7.2 Mapping of solutions to concepts

7.2.1 Mapping to concept 1 and 2

The changes listed in clauses and 7.1.1.3 and 7.1.2.3 are of different relevance for the different concepts. This is shown in table 7.2.1-1 .

	Relevant for	
Needed change	**Statistical ESM**	**Delegated ESM**
Modelling of Inter-RAT ESM thresholds for ES decisions	No	Yes
Modelling of Inter-RAT ESM thresholds for notification in case of traffic deviation	Yes	No
Desired Energy Saving state in UTRAN NRM	Yes	No
Actual Energy Saving state in UTRAN NRM	Yes	Yes
Modelling of ES coverage relations (two possible variants)	Yes	Yes
Add Energy Saving indications for RRC failure and cell unavailability	Yes	Yes

Table 7.2.1-1

7.2.2 Mapping to concept 3

Concept 3 introduces more information to be considered for deciding whether cell could do energy saving activation.

	Relevant for	
Needed change	**Statistical ESM**	**Delegated ESM**
Extend policy with additional information for energy saving activation decision	No	Yes

Table 7.2.2-1

8 Recommended solution(s)

The solutions in §7.1 satisfy all of the requirements for all of the concepts which are evaluated as useful. If a separation of the concepts needs to be supported in the object model (and if yes, how) is left for further work on stage 2 specification level. The same applies to the choice between solution in 7.1 and 7.2.

9 Conclusion

It is technically possible to manage the OAM aspects of Inter-RAT Energy Saving. A solution similar to the Intra-LTE solution is feasible, with some enhancements or alternative modelling.

Reuse of current Technical Specifications is likely. There is no obvious need for new Technical Specifications.

Some thresholds– and the related measurements - to control Inter-RAT ESM will be different compared to Intra-LTE ESM.

Intra-LTE ESM and Inter-RAT ESM can co-exist. A network operator should have the possibility to control which one has higher priority. For this suitable policies need to be defined.

Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2011-09	SA#53	SP-110517	--	--	Submission to SA for Information	-.-.-	1.0.0
2011-11	SA#54	SP-110698	--	--	Submission to SA for Approval	1.0.0	2.0.0
2012-01	--	--	--	--	Publication	2.0.0	11.0.0