3GPP TR 36.887 V0.1.0 (2013-05)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Study on Energy Saving Enhancement for E-UTRAN

(Release 12)

Keywords

UMTS, radio

3GPP

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Contents

Foreword

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

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Version x.y.z

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- x the first digit:
  - 1 presented to TSG for information;
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- 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

At present, sustainable development is a long-term commitment for all people in the world. This means not only development but also innovation. People should do their best to handle the resource shortage and environment deterioration. Therefore, how to improve the power efficiency and realize the power saving becomes a significant issue.

In the telecom area, most mobile network operators aim at decreasing the power consumption without too much impact on their network. In this case, the greenhouse emissions are reduced, while the OPEX of operators is saved.

Thus, the power efficiency in the infrastructure and terminal becomes an essential part of the cost-related requirements in network, and there is a strong need to investigate possible network energy saving solutions.

1 Scope

The present document is the technical report for the study item Study on Energy Saving Enhancement for E-UTRAN [2] which was approved at TSG RAN#58. The objectives of this study item are to identify potential solutions for energy saving scenarios for the LTE coverage layer scenario and the overlaid scenario and to perform their initial evaluation so that a subset of them can be used as the basis for further investigation and standardization. Furthermore, objectives are to identify intra-RAT energy saving issues and study corresponding energy savings solutions based on the defined use cases, requirements and deployment scenarios identified under Small Cell Enhancements Study Item.

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] RP-122035: "Study on Energy Saving Enhancement for E-UTRAN", CMCC.

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

[4] R3-130862: "Discussion on the twin state ES solution for LTE coverage layer", Fujitsu.

[5] R3-130972: "Energy Saving Enhancement Study on LTE Coverage Layer Scenarios", NEC.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] 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 [1].

3.2 Symbols

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

3.3 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].

eNB	enhanced NodeB
EPC	Evolved Packet Core
E-UTRAN	Evolved UTRAN
ES	Energy Savings
FFS	For Further Specification
LTE	Long Term Evolution
OAM	Operations, Administration, Maintenance
OPEX	Operating Expenses
RAN	Radio Access Network
SON	Self-Organizing Networks
TX	Transmission

4 Inter-eNB energy saving enhancement for overlaid scenario

4.1 Study on inter-eNB scenario

4.1.1 Description of scenario

The scenario for inter-eNB energy saving enhancement for overlaid scenario and corresponding requirements are similar to the scenario 1 for inter-eNB energy saving as described in TR 36.927 [3], but with the addition that different cells may offer different QoS and the QoS requirements of the UEs may be considered when switching on/off the capacity booster cell(s). For LTE network deployment, one possible application scenario of energy saving is described hereafter.

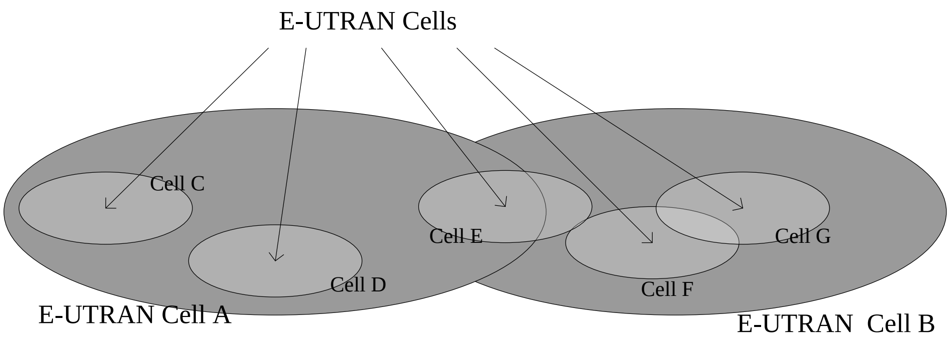

Figure 4.1-1: Overlaid scenario

Figure 4.1-1 shows the overlaid scenario in which E-UTRAN Cells C, D, E, F and G are covered by the E-UTRAN Cells A and B. Here, Cells A and B have been deployed to provide basic coverage, while the other E-UTRAN cells boost the capacity. When some cells providing additional capacity are no longer needed, they may be switched off for energy optimization. Conversely, the switched off cells may be activated when the network can benefit from the additional capacity they provide.

In principle, inter-eNB energy saving mechanisms should preserve the basic coverage in the network.

4.1.2 Solutions description

4.1.3 Solutions evaluation

5 Energy saving scenarios for LTE coverage layer

Scenarios for energy saving are scenarios where a LTE layer deployed according to network planning to provide coverage may offer opportunities to reduce the overall energy consumption.

Energy saving scenarios include cells switching off with compensation provided by neighbour cells and/or other energy saving methods, e.g. energy saving with Tx power optimization.

It is operator's concern to select appropriate areas where these methods can be applicable. Possible candidate areas are characterised by a network deployment that enables the extension of cells (i.e. not coverage limited) and areas where the traffic variation in time puts different requirements on the capacity (e.g. office areas, sports arenas).

5.1 Common requirements and constraints

The basic requirements for energy saving scenarios for LTE coverage layer are included in the scope of the study item on Network Energy Saving for E-UTRAN (TR 36.927 [3]). The following requirements are added:

a) Avoid coverage compensation if it is not necessary

b) Interference levels shall be approximately equal or lower when the network enters energy saving mode

c) UE QoS experience should be taken into consideration when developing energy saving solutions

The energy savings gain for LTE coverage layer scenarios may be limited by the increase in transmission power of compensation cells. As studied in [4], [5] a constraint for this scenario is that the energy saving action employed by the compensation cells should not increase their transmit power beyond the limit within which energy savings is achievable.

5.2 Single compensating eNB deployment scenario

5.2.1 Scenario description

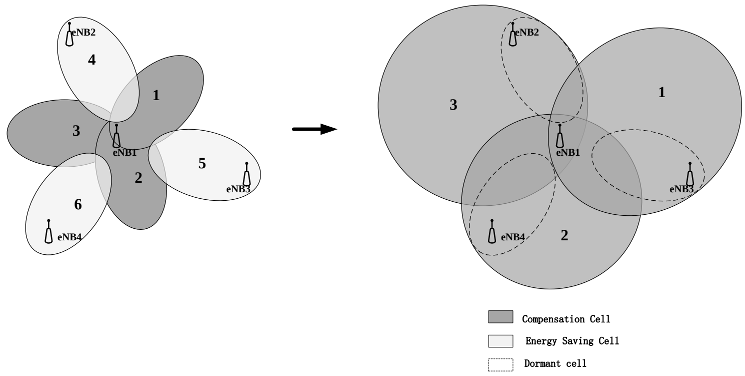

Figure 5.2.1-1: Single compensating eNB

A coverage layer of E-UTRAN cells is deployed. At off-peak time, energy saving cells which may belong to different eNBs (e.g., cell4 of eNB2, cell5 of eNB3 and cell6 of eNB4 in Figure 5.2.1-1) may enter dormant mode, while the basic coverage is provided by one or more cells of one eNB (e.g., cell 1, 2 and 3 of eNB1). Adjacent areas to the coverage provided by eNB1, eNB2 and eNB3 (cell 1-6) may have E-UTRAN coverage provided by eNBs not shown in Figure 5.2.1-1.

5.2.2 Solutions description

OAM configures which cells are switched off to reduce the power consumption and which cells are either switched on or re-configured to provide coverage replacing the coverage of the cells that are switched off.

OAM provides alternative configuration data to cells reconfigured to provide coverage originally provided by the switched off cells.

It is assumed that the different coverage configurations are obtained by careful network planning and testing.

It is assumed that only a very limited number of coverage configurations are realistic.

The following open issues are identified:

- By modifying the coverage, the MRO algorithm in neighbour cells may be impacted. It is FFS how to mitigate this.

- It is FFS if any new mechanisms to verify the different coverage configurations shall be studied.

- The signalling mechanism to be used for switch on/off cells is FFS.

- It is FFS if cells re-configured to provide compensation coverage should appear as different cells (i.e. different PCI and E-CGI).

- It is FFS if a scheme exists able to provide continuous service to RRC-Connected UEs during the transition to ES state.

5.2.3 Solutions evaluation

5.3 Multiple compensating eNBs deployment scenario

5.3.1 Scenario description

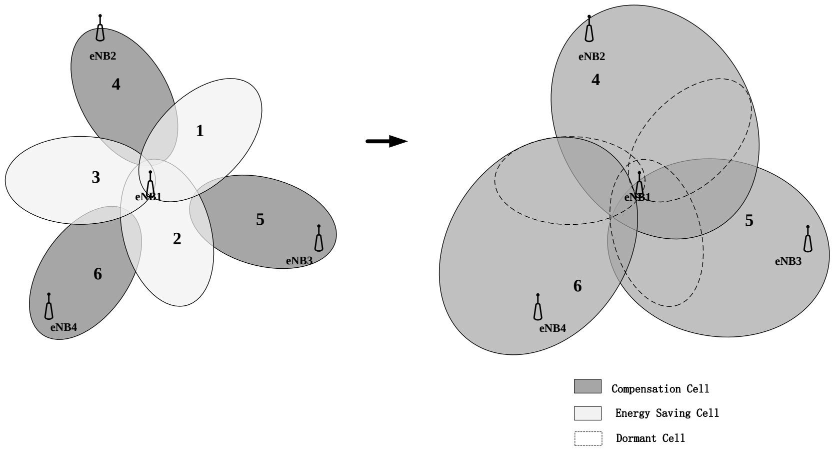

Figure 5.3.1-1: Multiple compensating eNBs deployment scenario

A coverage layer of E-UTRAN cells is deployed. At off-peak time, one or more cells (e.g., cell 1, 2 and 3 of eNB1 in Figure 5.3.1-1) of one or more eNB enter(s) dormant energy saving mode and two or more adjacent compensation cells belonging to different eNBs e.g., cell4 of eNB2, cell5 of eNB3 and cell6 of eNB4 in Figure 5.3.1-1) extend their coverage to provide basic coverage to UEs in dormant cells area. Adjacent areas to the coverage provided by eNB1, eNB2 and eNB3 (cell 1-6) may have E-UTRAN coverage provided by eNBs not shown in Figure 5.3.1-1.

5.3.2 Solutions description

OAM configures which cells are switched off to reduce the power consumption and which cells are either switched on or are re-configured to provide coverage replacing the coverage of the cells that are switched off.

OAM provides alternative configuration data to cells reconfigured to provide coverage originally provided by the switched off cells.

It is assumed that the different coverage configurations are obtained by careful network planning and testing.

It is assumed that only a very limited number of coverage configurations are realistic.

The following open issues are identified:

- By modifying the coverage, the MRO algorithm in the neighbour cells may be impacted. It is FFS how to mitigate this.

- It is FFS if any new mechanisms to verify the different coverage configurations shall be studied.

- The signalling mechanism to be used for switch on/off cells is FFS.

- It is FFS if cells re-configured to provide compensation coverage should appear as different cells (i.e. different PCI and E-CGI).
- It is FFS if a scheme exists able to provide continuous service to RRC-Connected UEs during the transition to ES state.
- It is FFS if multiple configurations should be defined to enable compensation by different subsets of neighbouring compensation cells.

5.3.3 Solutions evaluation

5.4 Transmission power optimization scenario

5.4.1 Scenario description

The scenario assumes the TX power of LTE cells can be reduced. This approach to save energy is to optimize the transmission power of all or most cells, so that without switching off any cell, overall energy consumption is minimized.

5.4.2 Solutions description

Solution 1

A distributed scheme where eNBs use mobility measurement (and possibly MDT measurements) collected from the UEs to estimate if there is any scope for TX power optimisation. There is no need to forward measurements between eNB. It is assumed that the allowed range of the power adjustment is controlled by OAM. The allowed range of the power adjustment guarantees a stable system, i.e. any combination of values selected by the eNBs involved in that scheme should not result in coverage holes, etc…

The need to negotiate or inform about changes of the transmit power between eNBs and which power to negotiate is FFS.

Solution 2

A centralized approach is used where OAM performs the transmit power adjustment with the help of MDT measurements collected by the eNB and forwarded to OAM.

5.4.3 Solutions evaluation

Annex A (informative): Change History

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	old	New
2013-04		R3-130784			Initial skeleton	N/A	N/A
2013-04		R3-130748			Text proposal on energy saving scenarios and requirements for LTE coverage layer	N/A	0.0.1
2013-04		R3-130749			Text proposal on the inter-eNB energy saving enhancement for overlaid scenario	N/A	0.0.1
2013-05		R3-131172			Inclusion of the agreed text proposals in R3-131146, and R3-131108	0.0.1	0.1.0