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Contents

Foreword

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Version x.y.z

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1 presented to TSG for information;

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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

This clause is optional. If it exists, it is always the second unnumbered clause.

1 Scope

This document captures the results of the study item on RAN Enhancements for UMTS/HSPA and LTE Interworking in RP-122036[2]. It identifies the existing mobility functions for HSPA and LTE interworking, the use cases and requirements for enhancements, and reviews and compares scenarios and techniques for enhancement of interworking functionality. The evaluation and comparison between existing and enhanced solutions is also included.

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-122036 Proposed SID: RAN Enhancements for UMTS/HSPA and LTE Interworking, China Unicom

[3] R3-130873 Discussion on Load Balancing Enhancements for Scenario 1, Huawei

[4] R3-131026 Load reporting mechanism enhancement, Samsung

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].

Definition format (Normal)

<defined term>: *<definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

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].

Abbreviation format (EW)

<ACRONYM> <Explanation>

4 General

In order to facilitate multi-RAT deployment and operation, there is a strong need to investigate possible mechanism for seamless UMTS/HSPA and LTE interworking. The aim of the study on as captured in the SI description document [RP-122036]:

- Investigate and evaluate mechanisms to enhance inter-RAT call redirection, connected mode mobility and load balancing between UMTS/HSPA and LTE.
    - Identify the suitable deployment scenarios and requirements, including LTE hotspot deployments
    - Investigate signalling optimisations and reduction in switching latency for both PS and CS services
- Identify the specification and implementation impacts affecting EUTRAN and UTRAN.

Unnecessary duplication of solutions addressing the same problem area shall be avoided. Performance and efficiency of the new solutions should all be compared against legacy. Moreover, the intention is to avoid UE impact as much as possible.

5 Requirements

Since the purpose of this study item is to investigate and evaluate mechanisms to enhance inter-RAT call redirection, connected mode mobility and load balancing between UMTS/HSPA and LTE, the following requirements should be considered for the enhancement/optimization.

1. The enhancement /optimization should reduce any signalling load to the CN compared to any existing standard mechanism.

2. The enhancement /optimization should reduce latency except backhaul when compared with any existing standard mechanism.

3. The enhancement /optimization should avoid UEs impacts.

4. The enhancement /optimization should focus on backwards compatible solutions for the RAN.

6 Target Scenarios for Enhancements

6.1 Scenario 1

One RAT (LTE or UMTS) is deployed for capacity improvement while the other RAT (UMTS or LTE) provides full overlapping coverage:

- Scenario 1a: UMTS provides full coverage where LTE provides only a partial coverage for capacity improvement
- Scenario 1b: LTE provides full coverage where UMTS provides only a partial coverage for capacity improvement

Examples of the deployment scenarios are captured in Figure 6.1.

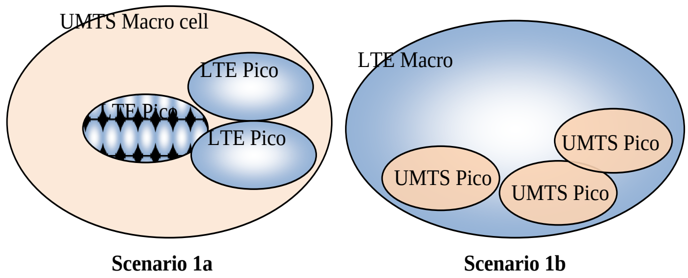

Figure 6.1 Examples of deployment scenarios for scenario 1

6.2 Scenario 2

One RAT (LTE or UMTS) provides coverage extension where the other RAT (UMTS or LTE) provides the basic coverage:

- Scenario 2a: UMTS provides basic coverage where LTE provides only a partial coverage for coverage extension
- Scenario 2b: LTE provides basic coverage where UMTS provides only a partial coverage for coverage extension

Examples of the deployment scenarios are captured in Figure 6.2.

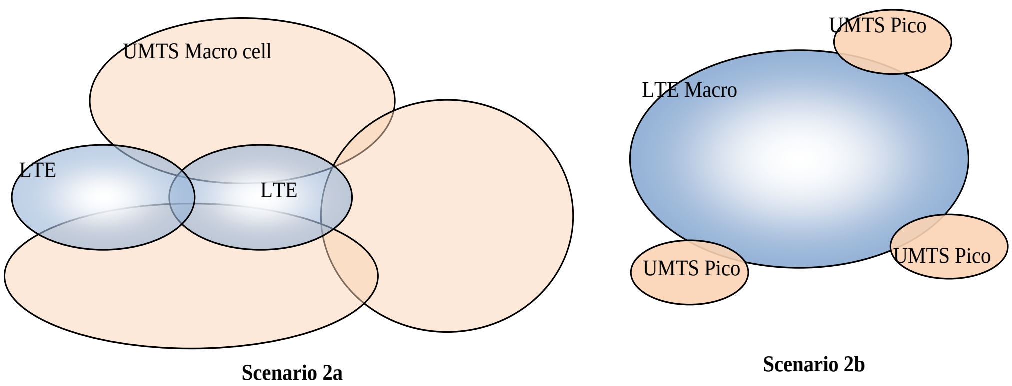

Figure 6.2 Examples of deployment scenarios for scenario 2

6.3 Scenario 3

In a certain area, both RAT (UMTS and LTE) have the full coverage, i.e. collocated coverage:

- Scenario 3a: In a certain area, both RAT (UMTS and LTE) have the full coverage, i.e. collocated coverage, while the coverage is provided by an MSR base station

An example of the deployment scenario is captured in Figure 6.3

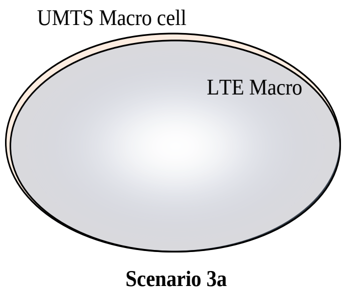

Figure 6.3 An example deployment scenario for scenario 3a

7 Enhanced Interworking: description and comparison of the different options

This chapter will identify possible improvements compared with the existing interworking and interoperation procedure, if any. Potential options list below could be beneficial to inter-RAT connected mobility, call redirection or load balancing.

7.1 Load balancing

7.1.1 Cell Load Reporting Enhancement for Scenario 1a

7.1.1.1 Enhancement aspects

(1) UTRAN cell load reporting enhancement to EUTRAN

Typically, in hot spot deployment, one UTRAN cell may have many neighbouring E-UTRAN cells who may belong to several eNBs. For purpose of load balancing, the load reporting of UTRAN cell and neighboring E-UTRAN cell should be exchanged between RNC and neighbouring eNBs.

For each time event-triggerred load reporting is triggered for one macro cell, RNC may duplicate the same load info for this cell in different RIM-PDUs going via the same SGSN and MME if the requested reporting threadsholds from different eNBs are same. More overlapping neighbouring eNBs there are, more duplicating information there would be. The load of the cell may quite dynamic, and would trigger the cell load reporting in a short period of time, e.g. every several minutes, thus it would be beneficial to consider the possible enhancement to reduce the duplicated UTRAN cell load reporting (CLR) for inter-RAT load balancing in scenario 1a.

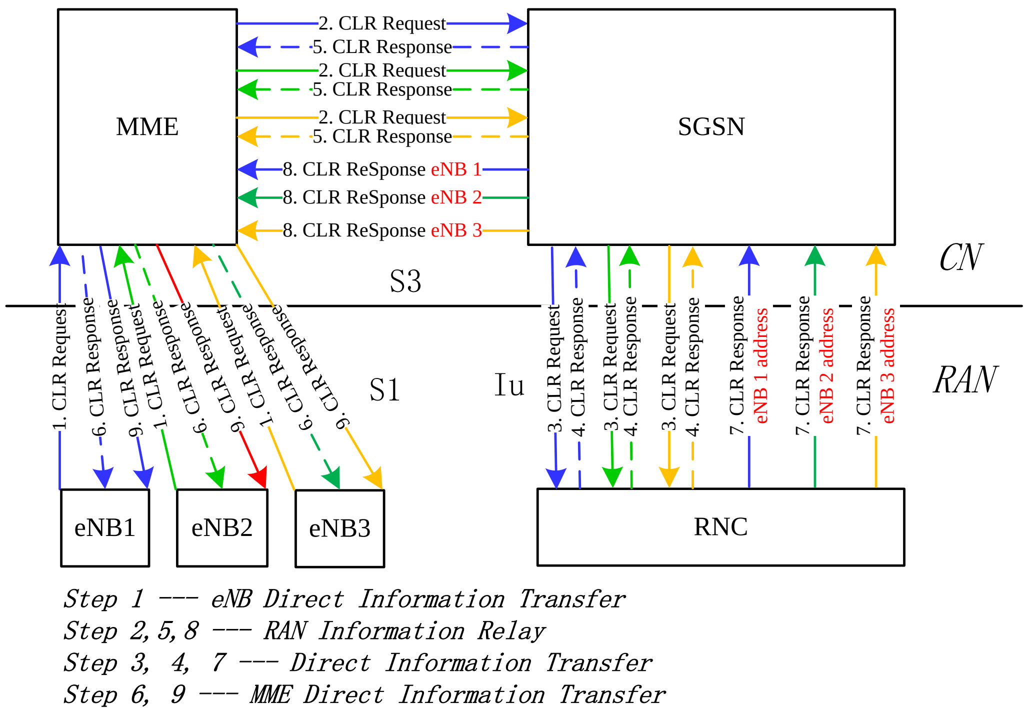

Figure 7.1.1 Current UTRAN Cell Load Reporting Procedure to LTE

(2) EUTRAN cell load reporting enhancement to UTRAN

In the current mechnisim, since *Destination Cell Identifier* and *Source Cell Identifier* in RIM PDU can only be set to one RNC-id or eNB id, each time one RIM PDU could only transfer information between one RNC and one eNB. For E-UTRAN cell load reporting acquiring in scenario 1a, the RNC could possibly need to send multiple RIM PDU to request EUTRAN cell load from multiple overlapping neighbouring eNBs. However, one of these eNBs may have already got the cell load of the rest of neighboring eNBs via current X2 RESOURCE STATUS UPDATE procedure.

Therefore, it would be beneficial to consider allowing RNC to request/acquire neighbouring E-UTRAN cell load that belongs to multiple eNBs with one single RIM PDU.

7.1.1.2 Solutions for UTRAN cell load reporting to E-UTRAN

7.1.1.2.1 Option1: Master eNB distributes UTRAN cell load response to slave eNBs

This solution is targeting to reduce the duplicated event triggering UTRAN cell load reporting in Iu, S3 and S1 interfaces. As shown in the Figure 7.1.1-1 below, in step 1~6, master eNB requests and acquires from the neighbouring RNC the UTRAN cell load information using existing RIM procedure [3]. In step 7, the Master eNB sends the UTRAN Cell load to salve eNB1, 2 and 3 via X2 interface based on the UTRAN cell load request from them in step0.

And in case of Event-triggered Cell Load Reporting, when the UTRAN cell load meets the reporting criterion, the RNC would send a report to the master eNB via SGSN and MME. Upon receiving the new cell load, the master eNB sends it to the slave eNB1, 2 and 3 in step 7 via X2 interface again.

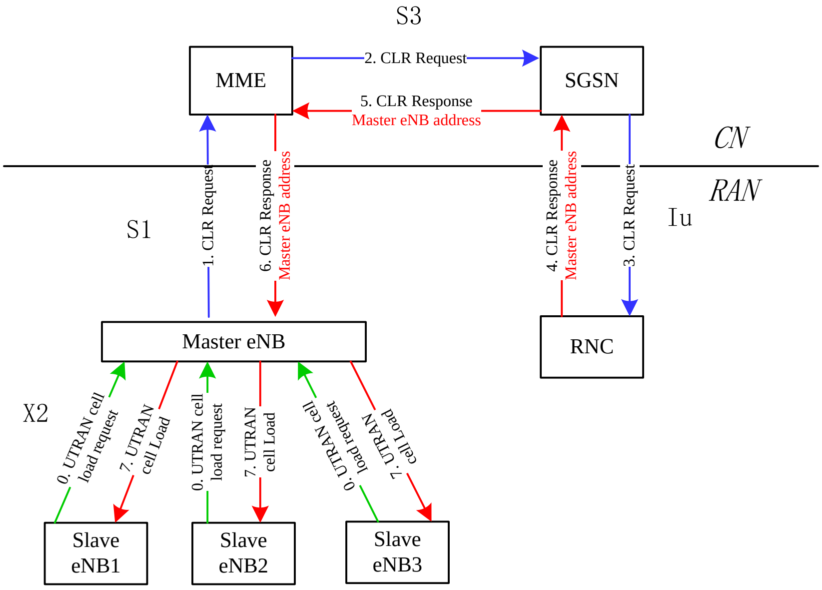

Figure 7.1.1-1 eNB distributes UTRAN cell load from master eNB to slave eNBs

In this solution, there is no impact to the RIM procedure among Master eNB, MME, SGSN and RNC. When the master eNB receives the UMTS cell load from the RNC, there are three ways for the master eNB to send the cell load to the slave eNBs:

Option-1-1: Master eNB would transfer the received RIM PDU which contains the requested/updated UTRAN cell load to slave eNBs with some modification. Before transfer, master eNB would change the *Destination Cell Identifier* from master eNB-id to slave eNB-id in the received RIM PDU.

Option -1-2: Master eNB would transfer the received RIM PDU which contains the requested/updated UTRAN cell load to the slave eNB directly without any modification. The slave eNBs who receives the RIM PDU should ignore the *Destination Cell Identifier* in the RIM PDU.

Option -1-3: Master eNB would derives the requested/updated UTRAN cell load from the RIM PDU and sends the UMTS cell load to the eNB via X2AP with new IE or new procedure, which is FFS.

Before requesting the UMTS cell load, the neighbouring eNBs of the UTRAN cell should be grouped. The eNB group could be configured by OAM or self established via new defined X2 AP procedure. Each eNB group could consist of several slave eNBs and one master eNB. The master eNB of the group could request/acquire the neighbouring UTRAN cell load reporting as agency for the other eNBs in the group.

There are only three slave eNBs (eNB 1, 2 and 3) (N=4) shown in the figure. The number of RIM PDU transmission via MME, SGSN and RNC will be decreased to 1/N by using enhanced RIM transmission as shown in Figure 7.1.1-1. The more slave eNBs are in the group, the more signalling reduction is achieved from the aspect of cost for the RIM-PDU transmission via the path of RNC/SGSN/MME/eNB.

Assumptions and observations:

- The same report level should be applied to all Slave eNBs, which is not as flexible as current specification
- In this option the grouping of slave eNBs needs to be configured beforehand.
- The master/slave architecture does not exist in the today's specification. To introduce a Master eNB may cause bottleneck problems when the Master eNB needs to broadcast load information among the slaves.

7.1.1.2.2 Option2: MME distributes UTRAN cell load response to the eNBs

This solution is targeting to reduce the duplicated event triggering UMTS cell load reporting in Iu, S3 interfaces.

As shown in Figure 7.1.1-2, each eNB requests cell load from the RNC using existing RIM procedure. RNC sends one combined RIM load reporting if all the eNBs request the same event threshold. The RNC reports the UTRAN cell load reporting via RAN Information to the MME, and this MME forwards the cell load reporting to different eNBs [4]. The MME gets the routing information in the RIM header.

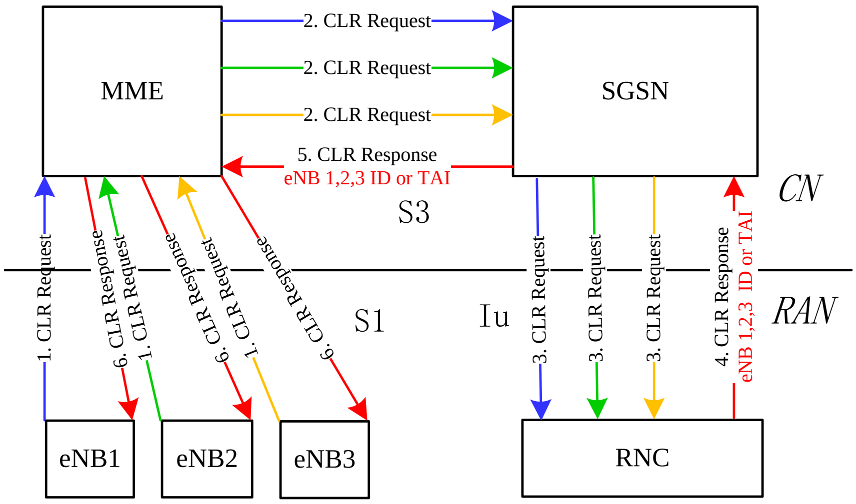

Figure 7.1.1-2 MME distributes UTRAN cell load to the eNBs

In this solution, eNB1, eNB2 and eNB3 request RNC about UTRAN cell load through MME and SGSN. No matter the eNBs' requests arrive at the same time or different time, MME and SGSN route them one by one. In another words, there is no change to the existing UTRAN cell load request procedure. With the received load request from eNB1, eNB2 and eNB3, if eNB1, eNB2 and eNB3 request the same report level, when the requested report event happens, the RNC can aggregate the load response according to the report level. The global eNB ID of eNB1, eNB2 and eNB3 with the same report level will be involved in the destination address for routing. Besides, if eNB1, eNB2 and eNB3 sharing the same TAI, the TAI can replace the global eNB ID in the destination address for routing. With the received load response from RNC, MME should understand the new destination address including the multiple eNB global IDs or TAI and distributes the load response messages over S1 interface according to the routing information: to the eNBs indicated by the global eNB ID or to the TAI.

Assumptions and observations:

- In order to distribute the UTRAN Cell load messages to multiple eNBs. MME is impacted to be able to understand the new destination address included in the RIM PDU, i.e. multiple target global eNB IDs or TAI, comparing to one target global eNB ID in current destination address.
- In order to reduce the load response messages, when the event of requested report level happens, the RNC should aggregates the load response to the eNBs which request the same report level. The signalling reduction level depends on the number of eNBs with the same requested report level.
- In this solution, the MME will not aggregate the cell load report request, because in most cases, the eNB1, 2, 3 will send requests to the MME in different time.

7.1.1.2.3 Option3: eNB distributes UTRAN cell load response to other eNBs

This solution is targeting to reduce the duplicated event triggering UTAN cell load reporting in Iu, S3 and S1 interfaces.

As showed in Figure 7.1.1-3, each eNB requests cell load from the RNC using existing RIM procedure. RNC sends one combined RIM load reporting if all the eNBs request same event threshold. The RNC reports the UTRAN cell load reporting via RAN Information to one eNB, and this eNB forwards the cell load reporting to other eNB via X2 [4]. The eNB gets the routing information in the SON Transfer Container. It assumes that there is an X2 interface between the eNB and the other eNBs.

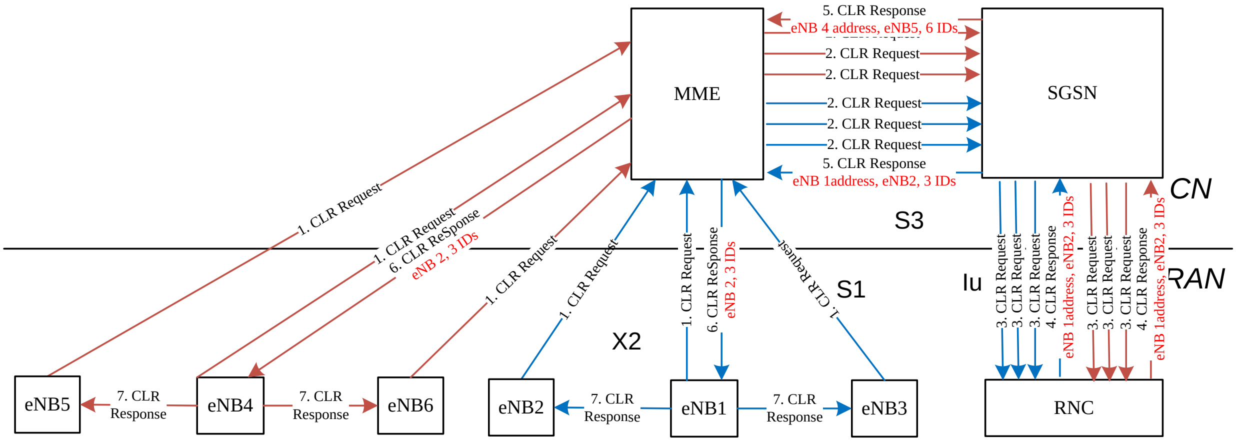

Figure 7.1.1-3 eNB distributes UTRAN cell load based on the routing info in SON Transfer Container

In this solution, the RNC adds the global eNB Id of eNB 2, 3 into the RIM PDU sent to eNB1, eNB1 distributes the UTRAN cell load to the eNB 2 and eNB3 via X2 accordingly.

Assumptions and observations:

- There is a configuration need to know and group the eNB1 ~ 3 that need the same load information from the same UMTS RNC.
- In order to reduce the load response messages, when the event of requested report level happens, the RNC should aggregates the load response to the eNBs which request the corresponding report level. The signalling reduction level depends on the number of eNBs with the same requested report level.
- In this option the grouping of eNBs is more flexible (with respect to option 1) and does not need to be pre-configured.
- The master/slave architecture does not exist in the today's specification. To introduce a Master eNB may cause bottleneck problem when the Master eNB needs to broadcast load information among the slaves.
- The neighbouring eNBs of the UTRAN cell should also be grouped. RNC will group the eNBs according to the OAM configuration and whether the same reporting level is requested by these eNBs.

7.1.1.3 Solutions for E-UTRAN cell load reporting to UTRAN

7.1.1.3.1 Option4: Master eNB aggregates EUTRAN cell load response of slave eNBs to RNC

This solution is targeting to reduce the signaling load of EUTRAN cell load reporting request/response in Iu, S3 and S1 interfaces.

As shown in the Figure 7.1.1-4, the RNC requests the master eNB for the E-UTRAN cell load of slave eNB 1, eNB 2 and 3 by setting *Destination Cell Identifier* as master eNB-id meanwhile setting *Reporting Cell Identifier* as cell ids those can belong to slave eNB1, eNB2, and eNB3 [3] [4]. Upon receiving the RIM PDU aims at cell load request, the master eNB checks whether the load of cells listed in the *Reporting Cell Identifier* is available. If not available, the master eNB need to identify which eNBs the cells in the *Reporting Cell Identifier* list belong to and request the cell load via X2. Afterwards, master eNB could encapsulate all requested E-UTRAN cell load in one single RIM PDU and send them to the RNC, if the requested events on different slave eNBs happen and the triggered cell load reportings from those eNB arrive the master eNB at the same time.

From specification point of view, it is now not explicitly forbidden to include cells belongs to multiple eNBs as *Reporting Cell Identifier*.

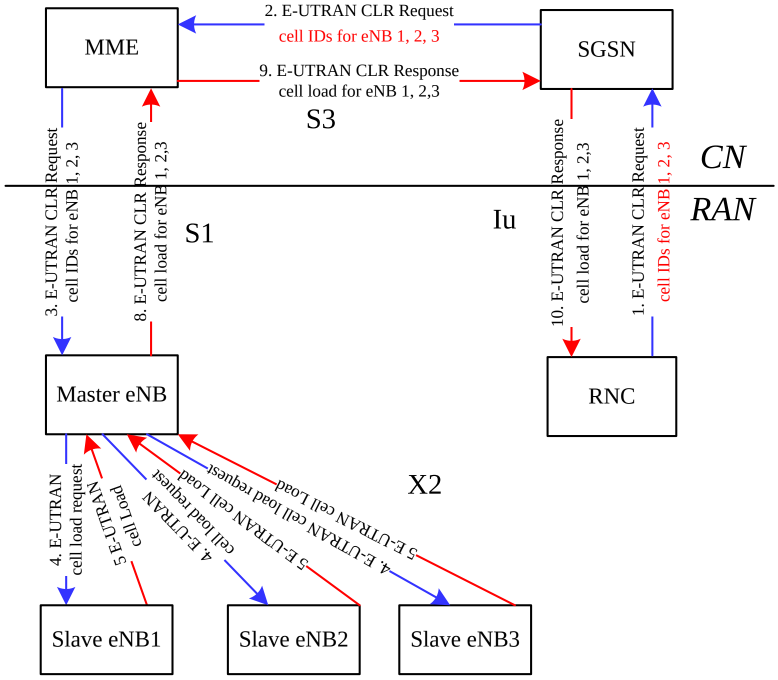

Figure 7.1.1-4 Multiple eNBs cell load request/response aggregattion in single RIM PDU

Before requesting the E-UTRAN cell load, the neighbouring eNBs of the UTRAN cell should be grouped. The eNB group could be configured by OAM or self established via new defined X2 AP procedure. Each eNB group would consist of several slave eNBs and one master eNB. The eNB group info could also be configured in RNC by OAM or received from the master eNB via new defined RIM procedure. Then, the RNC could request the master eNB for the load reporting of more than one eNBs of the group. Based on the request, the master eNB requests the cell load of the slave eNBs via X2 and then reports them to the RNC.

For simplicity, only three slave eNBs (eNB 1, 2, 3) are shown as an example in the figure (N=4). The number of RIM PDU transmission via MME, SGSN and RNC will be decreased to 1/N by using enhanced RIM transmission as shown in Figure 7.1.1-4. More eNBs in the group, more signalling reduction is achieved in the RIM-PDU transmission via the path of RNC/SGSN/MME/eNB.

Assumptions and observations:

- The same report level should be applied to Slave eNBs, which is not as flexible as current specification.
- The master/slave architecture does not exist in the today's specification. To introduce a Master eNB may cause bottleneck problem when the Master eNB needs to broadcast load information among the slaves.
- The Master eNB should record the report for the Slaves;
- The signaling reduction level depends on the number of requested events on different slave eNBs happen and the triggered cell load reporting from those eNB arrive the master eNB at the same time.

7.1.1.4 Evaluation and comparisons

Table 1 Evaluation metrics for related enhancements

	Solution 1	Solution n
Applicable Scenarios		
Signalling Reduction on S1/Iu		
Switching Latency Reduction		
Access network resource efficiency *		
Core network resource efficiency *		
UE Impact		
eNodeB Impact		
RNC/NodeB Impact		
CN Impact		

Note: * network resource efficiency means evaluation on resource occupation of network nodes which is unlikely to be quantified, and should be different from signaling reduction on specific interface.

** The description list in the metrics for each solution is compared with existing solutions, and thus provides uniform evaluation dimensions. Necessary entries can be added for different enhancement sections.

7.2 Inter-RAT Connected Mobility

7.2.1 Enhancement aspects

7.2.2 Solutions

7.2.2.1 Option 1

7.2.2.2 Option 2

7.2.2.n Option n

7.2.3 Evaluation and comparisons

Table 2 Evaluation metrics for related enhancements

	Solution 1	Solution n
Applicable Scenarios		
Signalling Reduction on S1/Iu		
Switching Latency Reduction		

Access network resource efficiency *		
Core network resource efficiency *		
UE Impact		
eNodeB Impact		
RNC/NodeB Impact		
CN Impact		

Note: * network resource efficiency means evaluation on resource occupation of network nodes which is unlikely to be quantified, and should be different from signaling reduction on specific interface.

** The description list in the metrics for each solution is compared with existing solutions, and thus provides uniform evaluation dimensions. Necessary entries can be added for different enhancement sections.

7.3 Inter-RAT Redirection

7.3.1 Enhancement aspects

7.3.2 Solutions

7.3.2.1 Option 1

7.3.2.2 Option 2

7.3.2.n Option n

7.3.3 Evaluation and comparisons

Table 3 Evaluation metrics for related enhancements

	Solution 1	**Solution n**
Applicable Scenarios		
Signalling Reduction on S1/Iu		
Switching Latency Reduction		
Access network resource efficiency *		
Core network resource efficiency *		
UE Impact		
eNodeB Impact		

RNC/NodeB Impact		
CN Impact		

Note: * network resource efficiency means evaluation on resource occupation of network nodes which is unlikely to be quantified, and should be different from signaling reduction on specific interface.

** The description list in the metrics for each solution is compared with existing solutions, and thus provides uniform evaluation dimensions. Necessary entries can be added for different enhancement sections.

8 Conclusion

This chapter will capture conclusions, agreements and recommendations for further work.

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2013-04	RAN3#79bis	R3-130602			Initial Skeleton with general requirements and target scenarios	N/A	0.0.1
2013-08	RAN3#81	R3-131386			Text proposal for evaluation metrics	0.0.1	0.1.0
2013-10	RAN3#81bis	R3-131798			Text proposal for cell load reporting enhancement Scenario 1a	0.1.0	0.2.0