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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Stage2 for Registration in Densely-populated area (RED);
Solution Placeholder
(Release 8)

**GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS**

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3GPP

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

3GPP

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

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

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Introduction

Big city such as Tokyo in Japan is densely-populated area and has a drastic change in population between daytime and night-time. For instance, in Tokyo, many mobile users move into a central area in the morning by jam-packed trains. This causes burst traffic, especially burst registration traffic around the centre of the city (e.g. around of Tokyo Loop line). Consequently, users around the border of LA/RA are unable to access communication service (voice or mail) for a certain time period due to congestion caused by burst LAU/RAU, regardless if they are in the train or not.

After the SA1 work (WI Unique ID: 350014), new WID for SA2 was established and during the SA2#59 it was requested from other interesting companies to draft a TR as solution placeholder. Therefore, this TR documents the proposed solution as a placeholder.

1 Scope

The objective is to provide the same user accessibility and user experience of communication services (e.g. voice or mail) around the areas near the LA/RA border, even when there is a big burst of registration traffic.

The present document identifies the appropriate solution and specifies the necessary function required to satisfy the service requirement.

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 TS 22.101: "Service aspects; Service principles ".

[3]   3GPP TS 23.002: "Network architecture".

[4]   3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[5]   3GPP TS 23.221: "Architectural requirements".

[6]   3GPP TS 23.236: "Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes".

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].

XA	extra Area
XAC	extra Area Code
XAI	extra Area Identifier

5 Architectural Requirements and Considerations

5.1 Background

SA1 WG considered that this has a lot of impact from RAN aspect and decided to send a LS to ask RAN2 WG for their advice on solution investigation.

RAN2 WG has then performed investigation, and the conclusion from RAN2 WG can be found in a LS (R2-072944). There were mainly two topics discussed in RAN2:

Firstly, RAN2 WG discussed about whether or not, this solution investigation is really necessary. There is a question whether already-3GPP-introduced way forward which was raised in RAN2 WG (putting majority of non-active user to URA_PCH state) solves this matter perfectly in every possible case. As to this, RAN2 concluded that whether an operator puts the majority of the non-active users to URA_PCH state or idle mode is an operator's decision, so relying on that solution only is not desirable. Therefore, the solution presented in this document is for idle mode.

Secondly RAN2 WG investigated the overall mechanism feasible to solve this issue as it is heavily relied on the RAN technology as follows.

- Expanding LA/RA

- Increasing the number of SCCPCH

- Introducing enhanced FACH

- Multi-TA like registration solution

RAN2 concluded that multi-TA-like registration solution should be considered as the most feasible, as it is described in the LS. In addition, we should note that LTE already decided to choose the multi-TA registration mechanism, which achieve same result as what RED is required to achieve.

Therefore, basic assumption on solution approach is to introduce the concept where multiple registration areas are grouped into one list and the UE may register to the list of multiple registration areas.

5.2 Architectural Requirements

- Impact to the current existing mobility / location management and call control procedure should be minimized.

- Solution is optional by which means whether to facilitate this new solution is based on network operator policy.

- If new registration area is introduced then that new registration area should be configurable to specific geographical area.

- The impact is contained in the RED capable UE and RED capable network.

- The solution should not degrade behaviour with respect to ping-pong effects.

6 Architecture Alternatives

Editor's note: For solution evaluation purpose, the description of effectiveness of each solution needs to be included in each alternative solution.

6.1 Multiple registration area with new registration area (XA) - Alternative 1

6.1.1 Architectural Details

6.1.1.1 General

The solution assumption is to use multiple registration areas which may be grouped into one list and UE may register that multiple registration areas. Currently, for the mobility functionality five different area concepts are used. LA and RA in the CN as well as UTRAN Registration Area, GERAN Registration Area and Cell areas in the Iu mode RAN.

This clause introduces the new registration area and presents an architectural alternative with this new registration area. This new registration area is called extra Area. Followings are the brief assumption of extra Area.

- XA is based on the network operator option.

- XA is configurable to specific geographical area.

- XA can be grouped into one list, XA list. Within this grouped area, UE may move around without location update.

- The XA capable network pages toward the multiple XAs contained in XA list.

- An extra Area does not cross a VLR area. An extra Area does not cross a SGSN area.

- The registration area consisted of multiple XAs (XA list) is contained in a pool area [6].

- XA list for CS domain and PS domain may be recognized or configured differently in UE and SGSN/VLR.

- In A/Gb mode, XAC is broadcast as system information in (Packet) Idle mode/Packet Transfer mode. XAC is also sent on dedicated channel for UE supporting Dual Transfer Mode. In Iu mode, XAC is broadcast as system information to MSs in RRC Idle mode, and is notified to MSs in RRC Connected mode on established RRC connections as CN information.

- XAI = MCC + MNC + LAC + RAC + XAC.

Editor's note: Whether or not we need XAI definition is FFS. There is another solution idea of not using XAI but to form a XA list with multiple extra areas. The solution is presented in this TR as another solution alternative.

The following figure shows the overview of extra Area solution mechanism for UTRAN and GERAN with e.g., location management - combined procedure (Intra SGSN procedure).
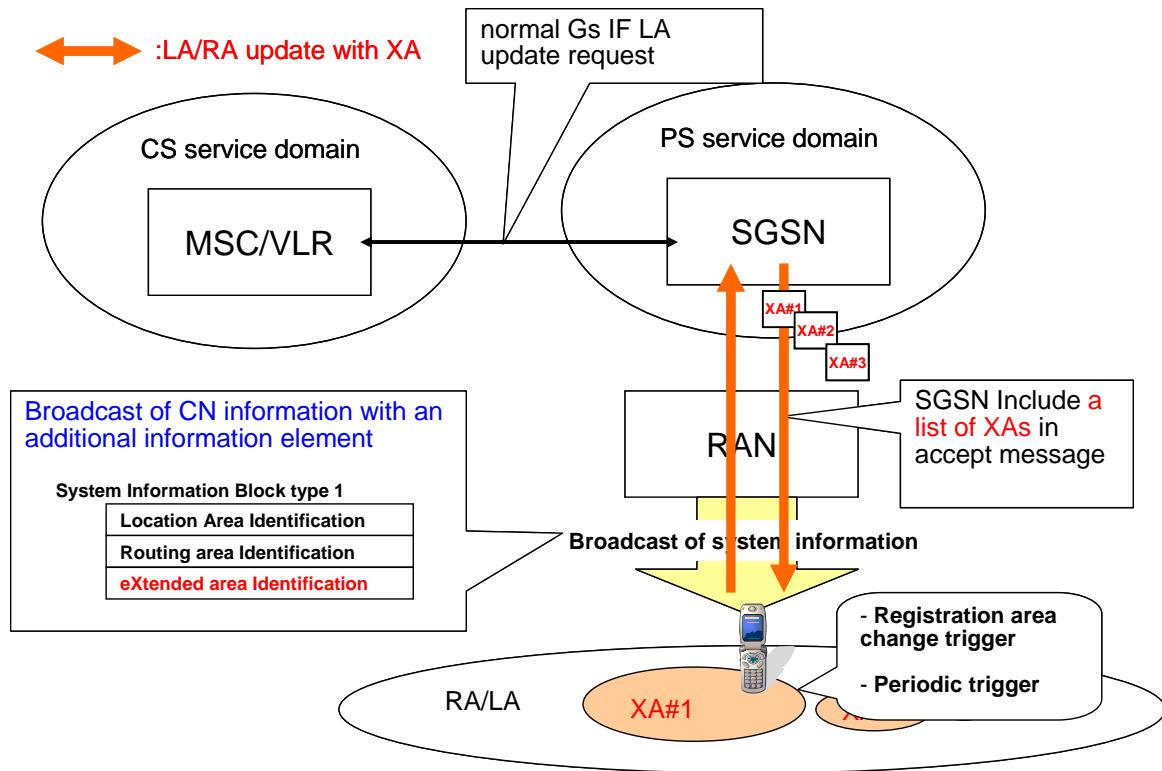
Figure 6.1.1.1: Overview of alternative solution 2 with e.g., location management – combined procedure

Editor's note: The functionality allocation on allocation of XA list in CS domain and PS domain is FFS.

6.1.1.2 Area Concept

For CS/PS services, based on network operator option, the CN uses XA. In order to avoid excessive location management signaling, it may consist of a group of XAs called XA list. XA list for the CS and of the PS domain may be configured independently with the granularity of each XA. The list of XAs is used e.g. at CN initiated paging related to CS/PS services. XA list can be created over multiple LAs/RAs. XA is common area for the two CN domains (CS and PS).

6.1.1.2.1 Relationship with other areas

This new registration area is called extra Area. For CS/PS services, based on network operator option, the CN uses

A network operator may support extra area concept in addition to other area concepts such as LA and RA in the CN as well as UTRAN Registration Area, GERAN Registration Area.

The following area relations exist:

The relation presented in the following clauses does not represent the complete set of possibilities, nor does it mandate this kind of area configuration.

- there need not be any relation between URA/GRA and XA;

- one XA consists of a number of cells belonging to RNCs or BSCs that are connected to the same CN node;

- one XA is handled by only one CN serving node, i.e. one combined MSC+SGSN or one 3G_SGSN or one 3G_MSC/VLR;

- the registration area consisted of multiple XAs (XA list) is contained in a SGSN/VLR area;

- a registration area consists of multiple XAs (XA list) may span out of a SGSN/VLR area with the concept of Intra Domain Connection of RAN Nodes to Multiple CN Nodes [6];

- the XA list for PS domain is smaller than or equal to the XA list for CS domain.

- The XA lists assigned to a UE can be overlapping, i.e. the new XA list assigned to a UE at Routing Area Update can define a routing area that is overlapping with the area defined by the old XA list.Following figure shows the relationship of LA, RA, XA, and URA/GRA.
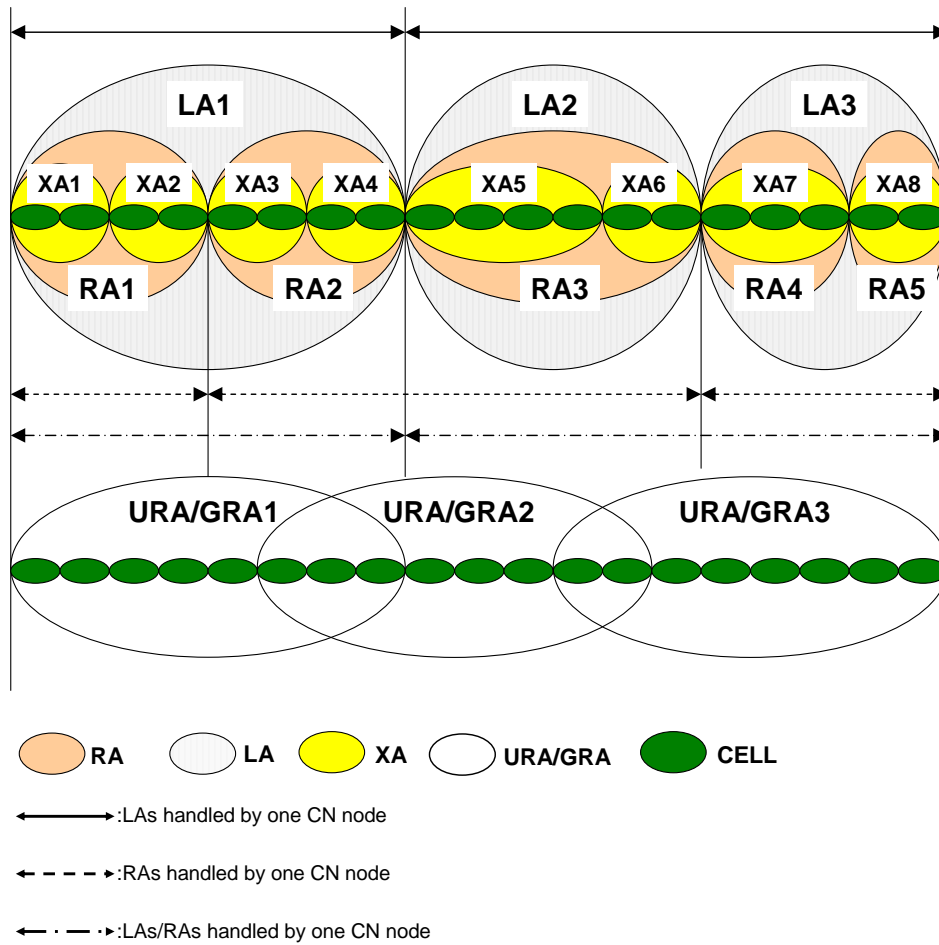
Figure 6.1.1.2.1-1: Relationship between extra area and different areas

Following figure shows a possible extra area configuration with list concept.

[XA list for PS domain]
XA list (a) : XA1; XA list (b) : XA2, 3; XA list (c) : XA4; XA list (d) : XA5;
XA list (e) : XA6, 7; XA list (f) : XA8

[XA list for CS domain]
XA list (A) : XA1; XA list (B) : XA2, 3, 4; XA list (C) : XA5; XA list (D) : XA6, 7, 8

RA   LA   XA   URA/GRA   CELL

:A PS registration area consisted of multiple XAs (XA list for PS domain)

:A CS registration area consisted of multiple XAs (XA list for CS domain)

:XAs for PS handled by one CN node

:XAs fo CS handled by one CN node

Figure 6.1.1.2.1-2: extra area configuration with list concept

NOTE: These figures shows technically it is possible to have configuration where XA list for CS domain and XA list of PS domain are different; however, it is consensus that with normal configuration, the XA list for CS and PS domain is the same.

Editor's note: The functionality allocation on allocation of XA list in CS domain and PS domain is FFS.

Following figure depicts overview of registration trigger for user resides in XA. The point here is unlike LA/RA and like TA for LTE, XA can be bundled together to create a list of XAs, and the UE understands this list as a registration area which means the UE move around without location update.
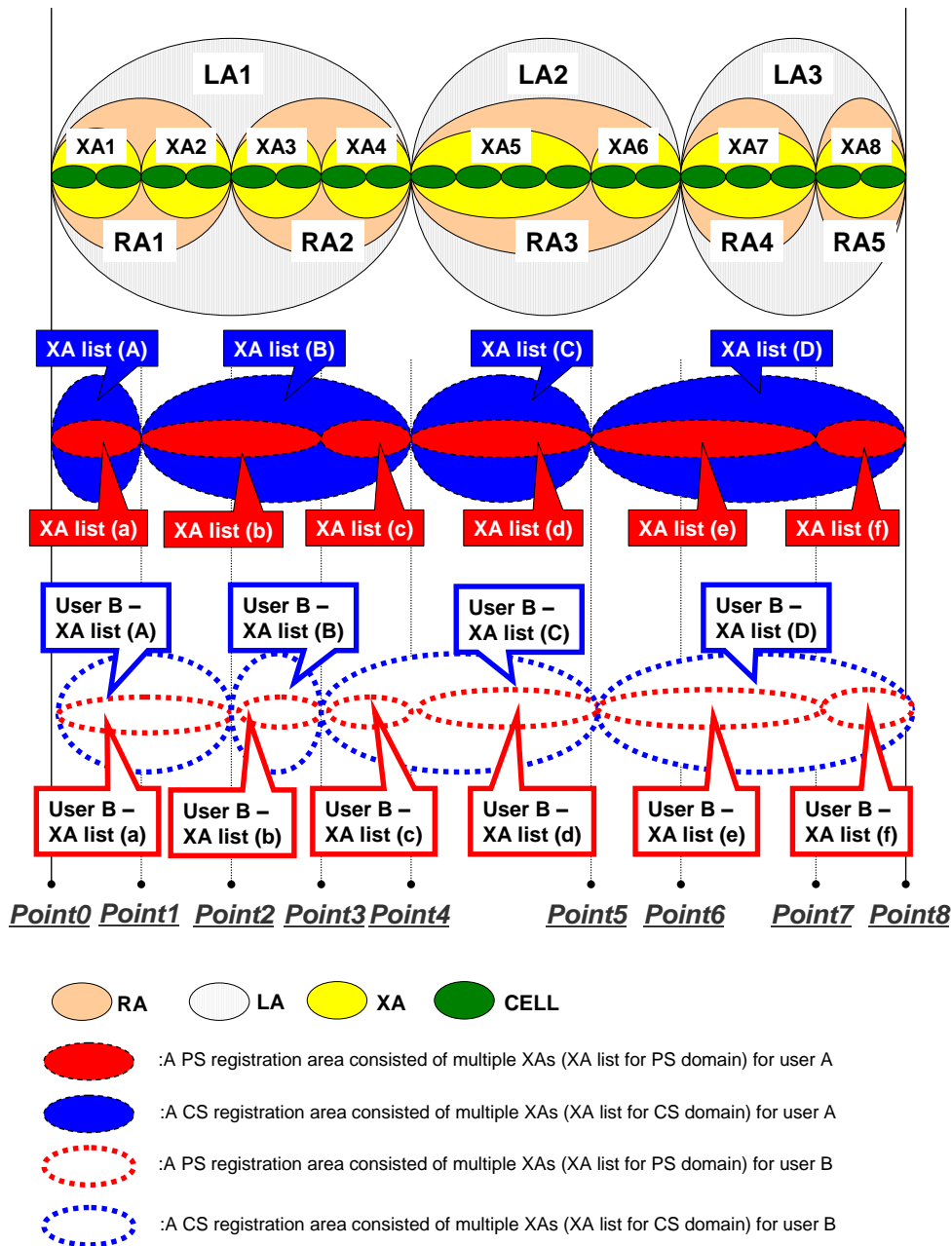
Figure 6.1.1.2.2: Overview of registration in extra Area

With current registration area configuration (LA/RA), for idle mode, registration point for user A and user B would be the same. On the other hand, by allocating multiple extra areas to the UE, registration timing may be different for each user as it is shown in the Figure 6.1.1.2.2. For example, at point 1, user A performs registration procedure, but user B will not; instead, user B performs registration procedure at point 2 where user A will not.

6.1.1.3 Overview of Mobility / Location Management

6.1.1.3.1 Non-combined procedure

In RRC Idle mode (Iu mode), or in (Packet) Idle mode/Packet Transfer mode (A/Gb mode), it is the broadcast MM system information (e.g. information about the present LA and present RA and present XA) that determines when the UE initiates a location registration procedure towards the CN. If the network operator supports XA concept, the following procedure may be initiated.

- An UE crossing an LA border and moving into XA, in state CS-IDLE, shall initiate LA update towards the CN with the present XA. An UE crossing an RA border and moving into XA, in state PS-IDLE/GMM standby/GMM ready, shall initiate RA update towards the CN with the present XA.

- An UE crossing an XA border and changing the XA to the one which is not assigned to the UE as a XA list for CS domain, in state CS-IDLE, shall initiate LA update with the present XA. An UE crossing an XA border and changing the XA to the one which is not assigned to the UE as a XA list for PS domain, in state PS-IDLE/GMM standby/GMM ready, shall initiate RA update, instead of a cell update in the case of GMM ready, with the present XA.

- An UE crossing an XA border and moving into the LA, in state CS-IDLE and RRC Idle mode, shall initiate LA update. An UE crossing an XA border and moving into the RA, in state PS-IDLE/GMM standby/GMM ready, shall initiate RA update.

In RRC Connected mode (Iu mode only), the UE receives the MM system information on the established RRC connection. (I.e. the broadcast MM system information is not used by the UE in the RRC connected mode.) If the network operator supports XA concept, the following procedure may be initiated.

- An UE receiving information indicating XA availability and a new XA which is not assigned to the UE, in state CS-IDLE, shall initiate LA update towards the CN with the present XA.

- An UE receiving information indicating XA availability and a new XA which is not assigned to the UE, in state PS-IDLE, shall initiate RA update towards the CN with the present XA.

In Dedicated mode or Dual Transfer mode (A/Gb mode only), a UE supporting Dual Transfer mode receives area information on dedicated channel (i.e. SI6). The following procedure may be initiated

- An UE receiving information indicating XA availability and a new XA which is not assigned to the UE shall initiate RA update towards the CN with the present XA.

If the XA availability indication is provided, an UE shall initiate necessary location management procedure according to the XA related information provided. If the XA availability indication is not provided, UE shall initiate location management procedure according to LA/RA related information.

NOTE: An UE receiving no information of a new LA/RA, a new XA nor the XA availability indication, UE should perform LA update or RA update respectively when moving into LA/RA from XA. How and with what information a UE performs such procedure is FFS.

6.1.1.3.2   MM functionality in different UE service states

CS service states and related MM functionality:

- CS-DETACHED: The UE is not reachable by the network for CS services. The UE does not initiate LA updates at LA changes and no periodic CS service updates;

- CS-IDLE: The UE is reachable by paging for CS services. The UE initiates LA updates at LA changes or changes of XA to the one which is not included in the XA list is not assigned to the UE for CS domain. The UE may initiate periodic CS service updates and this depends on the CS periodic update state of the present LA or XA;

- CS-CONNECTED: The UE has a signalling connection for CS services established between the UE and the CN. The UE does not initiate LA update (even not when the present LA changes or XA changes) and no periodic CS service updates.

PS service states and related MM functionality:

- PS-DETACHED (Iu mode) or GMM Idle(A/Gb mode): The UE is not reachable by the network for PS services. The UE does not initiate RA updates at RA changes and no periodic PS service updates;

- PS-IDLE (Iu mode) or GMM standby(A/Gb mode): The UE is reachable by paging for PS services. The UE initiates RA updates at RA changes or changes of XA to the one which is not assigned to the UE for PS domain. The UE may initiate periodic PS service updates and this depends on the PS periodic update state of the present RA or XA;

- GMM ready(A/Gb mode only): The UE is in packet data transfer. The UE shall perform cell update each time a new cell is selected. The UE initiates RA updates, instead of a cell update, at RA changes or changes of XA to the one which is not assigned to the UE for PS domain. The UE may initiate periodic PS service updates and this depends on the PS periodic update state of the present RA or XA;

- PS-CONNECTED (Iu mode only): The UE has a signalling connection for PS services established between the UE and the CN. The UE initiates RA update when RAI in MM system information changes or XA availability indication is indicated and XAI changes to the one which is not assigned to the UE for PS domain. No periodic PS service updates.

6.1.1.4 Service registration and location update

6.1.1.4.1 Location area update

LA update is initiated by the UE to inform the CS domain of the CN that the UE has entered a new LA or moved into LA from XA if a network operator supports the XA concept. If a network operator supports the XA concept, LA update with the present XA is initiated by the UE to inform the CS domain of the CN that the UE has entered a new XA which is not included in the assigned list of XAs for CS domain or moved into XA from LA/RA. In case the new LA or XA is in an area served by another CN node, the LA update also triggers the registration of the subscriber in the new CN node and a location update for CS services towards the HLR.

LA update is only initiated by the UE when the UE is in state CS-IDLE, and this independently of the PS state. In Iu mode, if the UE is CS-IDLE but RRC connected, which means that the UE is in PS-CONNECTED state, LA update is initiated by the UE when it receives information indicating a new LA. If a network operator supports the XA concept, LA update with the present XA is initiated by the UE when it receives information indicating the XA availability and a new XA which is not included in the assigned list of XAs for CS domain. In case UE has not received information of XA availability indication but new LA indication, the LA update with the present LA is initiated.

6.1.1.4.2 Routing area update

RA update is initiated by the UE to inform the PS domain of the CN that the UE has entered a new RA or moved into RA from XA if a network operator supports the XA concept. If a network operator supports the XA concept, RA update with the present XA is initiated by the UE to inform the CS domain of the CN that the UE has entered a new XA which is not included in the assigned list of XAs for PS domain or moved into XA from LA/RA. In case the new RA or XA is in an area served by another CN node, the RA update also triggers the registration of the subscriber in the new CN node and a location update for PS services towards the HLR.

RA update is initiated by the UE when the UE is in state PS-IDLE/GMM standby/GMM ready, and this independently of the CS state. In Iu mode, if the UE is PS-IDLE but RRC connected, which means that the UE is in CS-CONNECTED state, RA update is initiated by the UE when it receives information indicating a new RA. In A/Gb mode, the UE supporting Dual Transfer Mode initiate RA update when it receives information indicating a new RA on dedicated channel. If a network operator supports the XA concept, RA update with the present XA is initiated by the UE when it receives information indicating the XA availability and a new XA which is not included in the assigned list of XAs for PS domain. In case UE has not received information of XA availability indication but new RA indication, the RA update with the present RA is initiated.

When the UE is in PS-CONNECTED state the UE initiates RA update when RAI in MM system information changes or XA availability indication is indicated and XAI in MM system information changes to the one which is not assigned to the UE.

6.1.1.5 Relations between SRNS relocation and location registration (Iu mode only)

The figure 6.1.1.5 illustrates an example in case a network operator supports the XA concept.

Preconditions (see figure 6.1.1.5):

- LA1 is handled by 3G_MSC/VLR1 and LA2 is handled by 3G_MSC/VLR2 and LA3 is handled by 3G_MSC/VLR3 and LA4 is handled by 3G_MSC/VLR4;

- RA1 is handled by 3G_SGSN1 and RA2 is handled by 3G_SGSN2 and RA3 is handled by 3G_SGSN3 and RA4 is handled by 3G_SGSN4;

- UE A, UE B, and UE C are all XA concept capable;

- XA2-1 and XA2-2 are grouped together and assigned to the UE as one registration area;

- XA3-1 and XA3-2 are grouped together and assigned to the UE as one registration area.

The precondition specific to UE A:

- UE A is registered in LA 1 in 3G_MSC/VLR 1 and in RA 1 in 3G_SGSN 1;

- UE A is in PS-CONNECTED state and a signalling connection exists between UE and 3G_SGSN 1;

- UE A is in CS-IDLE state and no signalling connection exists between UE and 3G_MSC/VLR 1;

- RNC1 is acting as SRNC and RNC2 is acting as DRNC;

- UE is in RRC cell connected state and with dedicated channels established to cells within both RNC1 and RNC2. UE does not listening to the PCH;

- the registration area information sent to the UE indicates LA1 and RA1.

The precondition specific to UE B:

- UE B is registered in LA 2 in 3G_MSC/VLR 2 and in RA 2 in 3G_SGSN 2;

- UE B is in PS-CONNECTED state and a signalling connection exists between UE and 3G_SGSN 2;

- UE B is in CS-IDLE state and no signalling connection exists between UE and 3G_MSC/VLR 2;

- RNC2 is acting as SRNC and RNC3 is acting as DRNC;

- UE is in RRC cell connected state and with dedicated channels established to cells within both RNC2 and RNC3. UE does not listening to the PCH;

- the registration area information sent to the UE indicates LA2 and RA2.

The precondition specific to UE C:

- UE C is registered in LA 3 in 3G_MSC/VLR 3 and in RA 3 in 3G_SGSN 1;

- UE C is in PS-CONNECTED state and a signalling connection exists between UE and 3G_SGSN 3;

- UE C is in CS-IDLE state and no signalling connection exists between UE and 3G_MSC/VLR 3;

- RNC3 is acting as SRNC and RNC4 is acting as DRNC;

- UE is in RRC cell connected state and with dedicated channels established to cells within both RNC3 and RNC4. UE does not listening to the PCH;

- the registration area information sent to the UE indicates LA3 and RA3.
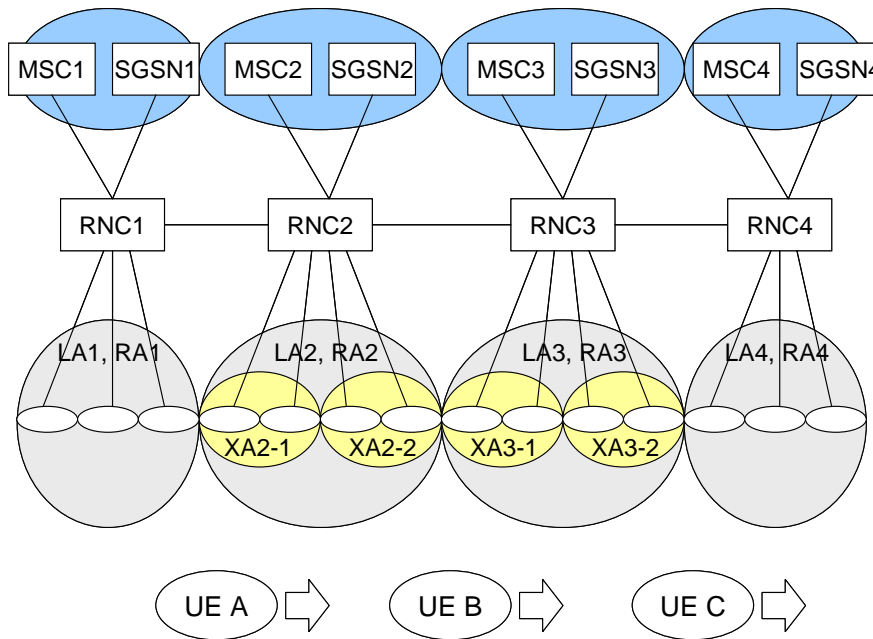
Figure 6.1.1.5: Illustration of the preconditions in the described example for XA concept supported

The UE moves now further towards the right, leaving the coverage area of cells controlled by SRNC, and resulting in that the UE has dedicated channel(s) established to cell(s) within only DRNC. This can result in the following sequence of events:

- the SRNC can decide to perform an SRNC relocation. In this example, the change of SRNC also implies a change of SGSN with an update of the UE location registration for the PS domain;

- after this SRNC relocation or combined with this procedure, the CN information (the UE receives the MM system information on the established RRC connection, and the broadcast MM system information is not used by the UE in the RRC connected mode.) sent to the UE is changed and indicates as shown in the following for each case(UE A, UE B, and UE C);

  a) For UE A, the CN information element indicates now XA2 (XA2-1 and XA2-2) and XA availability in that area.

  b) For UE B, the CN information element indicates now XA3 (XA3-1 and XA3-2) and XA availability in that area.

  c) For UE C, the CN information element indicates now LA4 and RA4.

NOTE 2a: The MM registration area information need not be sent for every SRNS relocation, nor does it preclude MM registration area information being sent in other occasions.

- the UE initiates a LA update as it described in the following for each case(UE A, UE B, and UE C);

  a) LA updates with XA2-1 or XA2-2, which results in a registration change from LA1 in 3G_MSC/VLR1 to new group of XAs (XA2-1 and XA2-2) in 3G_MSC/VLR2 and results in changed MM registration information.

  b) LA updates with XA3-1 or XA3-2, which results in a registration change from old group of XAs (XA2-1 andor XA2-2) in 3G_MSC/VLR2 to new group of XAx (XA3-1 and XA3-2) in 3G_MSC/VLR3 and results in changed MM registration information.

  c) LA updates, which results in a registration change from old group of XAs (XA3-1 and XA3-2) in 3G_MSC/VLR3 to LA4 in 3G_MSC/VLR4 and results in changed MM registration information.

NOTE 3a: The area information can not be changed to indicate new area unless SRNC relocation has been performed, because the LA update signalling is sent from the UE, by using the established RRC connection to SRNC, and then to the 3G_MSC/VLR to which the SRNC belongs.

6.1.1.6 Call control

The structured function and procedure on Stage2 level is the same as it is already defined.

The mobile station initiates immediate assignment, service request using the CM SERVICE REQUEST message, and contention resolution. The network may initiate authentication and may start the ciphering mode setting. The mobile station shall include current location information (XAI) in the message.

The paging procedure is used to locate a mobile station to which a connection shall be established. Upon receipt of a PAGING REQUEST message the addressed mobile station initiates the immediate assignment procedure. On the RANAP message, XA list of CS domain or/and PS domain are included.

Mobile terminating call establishment is initiated by the network sending a PAGING REQUEST message. Upon receiving this message the mobile station initiates the immediate assignment procedure and responds to the network by sending the PAGING RESPONSE message. The mobile station shall include current location information (XAI) in the message.

The impact and functional capability for PS domain is the same as the ones described above. In Iu mode, the service request message shall include location information (XAI) to initiate PS access. In A/Gb mode, in order to initiate PS access UE sends any LLC frame (including paging response), with which BSS informs location information (XAI) as well as RAC and LAC to SGSN.

6.1.2 Procedures

6.1.2.1 Mobility / Location management

6.1.2.1.1 Location Area update with XA concept

If a network operator supports the XA concept, location registration procedure shown in figure 6.1.2.1.1.* is initiated in following cases.

   a) In the case where UE moves into XA from LA or vice versa.

   b) In the case where XA changes to a new XA which is not assigned yet.

In the case where UE moves into LA from XA, Location Area update procedure is initiated.

6.1.2.1.1.1 Location Area update with XA concept (Iu Mode)

The illustrated transfer of MM signalling to/from the UE uses an established RRC connection. This RRC connection can have been established beforehand due to ongoing interwork between UE and 3G-SGSN or be established only for this location registration procedure towards the 3G_MSC/VLR.

Attach and Location registration request messages do not contain old XA. MSC or SGSN which receives Attach or Location registration request derives which XA the UE belongs to, if 'XA capability' is sent from the UE and the XAI is sent from RNC to MSC/SGSN, and returns a new XA list to the UE in Attach / Location registration accept message.

XA capable UE only sees XA while it is moving, and can send Location registration request when it crosses the border of its XA list, based on the comparison between XAC broadcasted in the XA and the XA list stored in the UE.

For each indicated MM message sent in this case to/from UE, the CN discriminator indicates 3G_MSC/VLR.
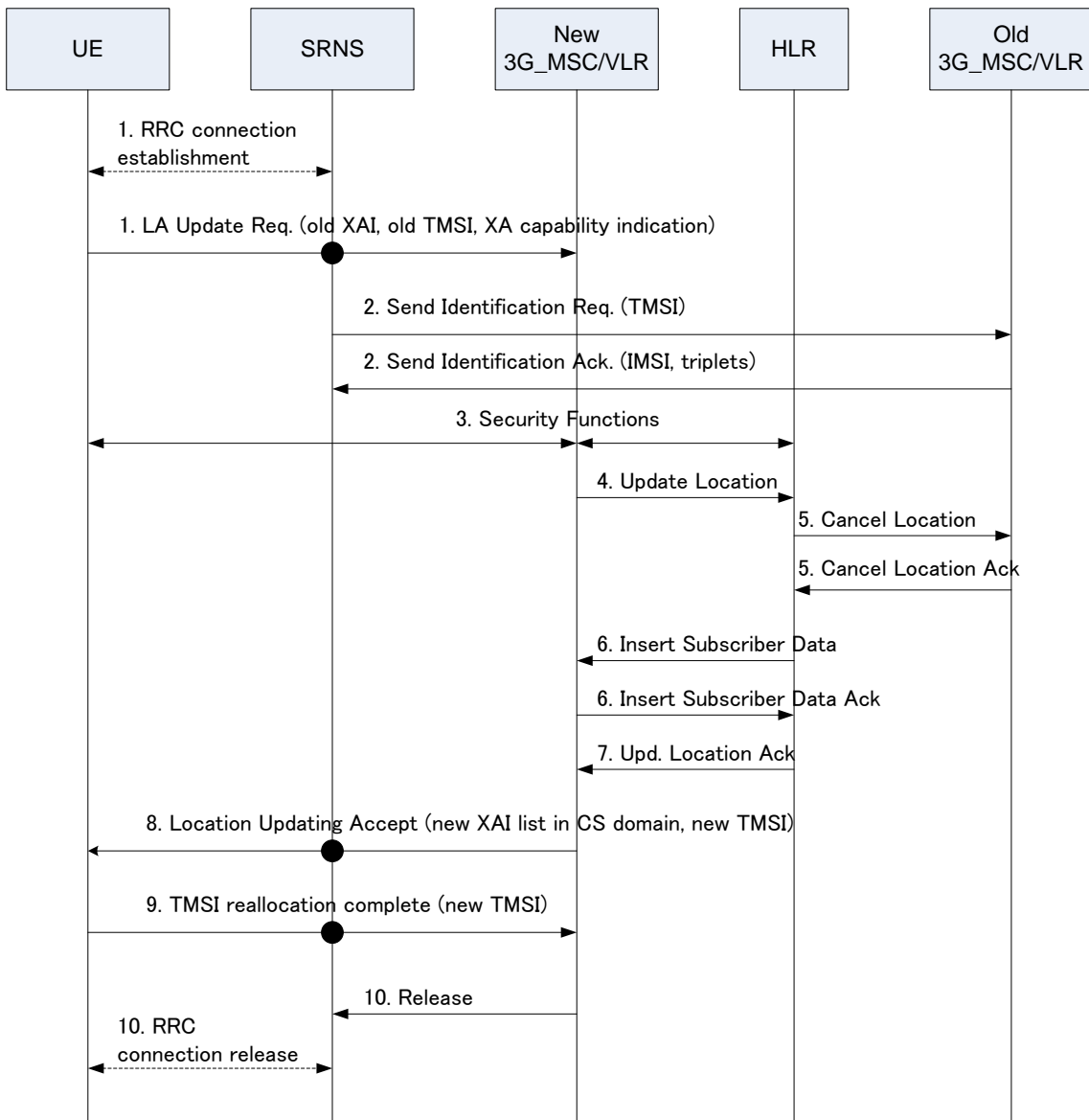
Figure 6.1.2.1.1.1: Interface information transfer for location update with XA when changing VLR area (Iu Mode)

1   The RRC connection is established, if not already done. The UE sends the initial message LA Update Request (old TMSI, old LAI, and XA capability indication, etc.) to the new 3G_MSC/VLR. The old TMSI and LAI are those that were assigned to the UE, and XA capability indicates that the UE is XA concept capable. The SRNS transfers the message to the 3G_MSC/VLR

NOTE: The sending of this message to 3G_MSC/VLR also implies establishment of a signalling connection between SRNS and 3G_MSC/VLR for the concerned UE.
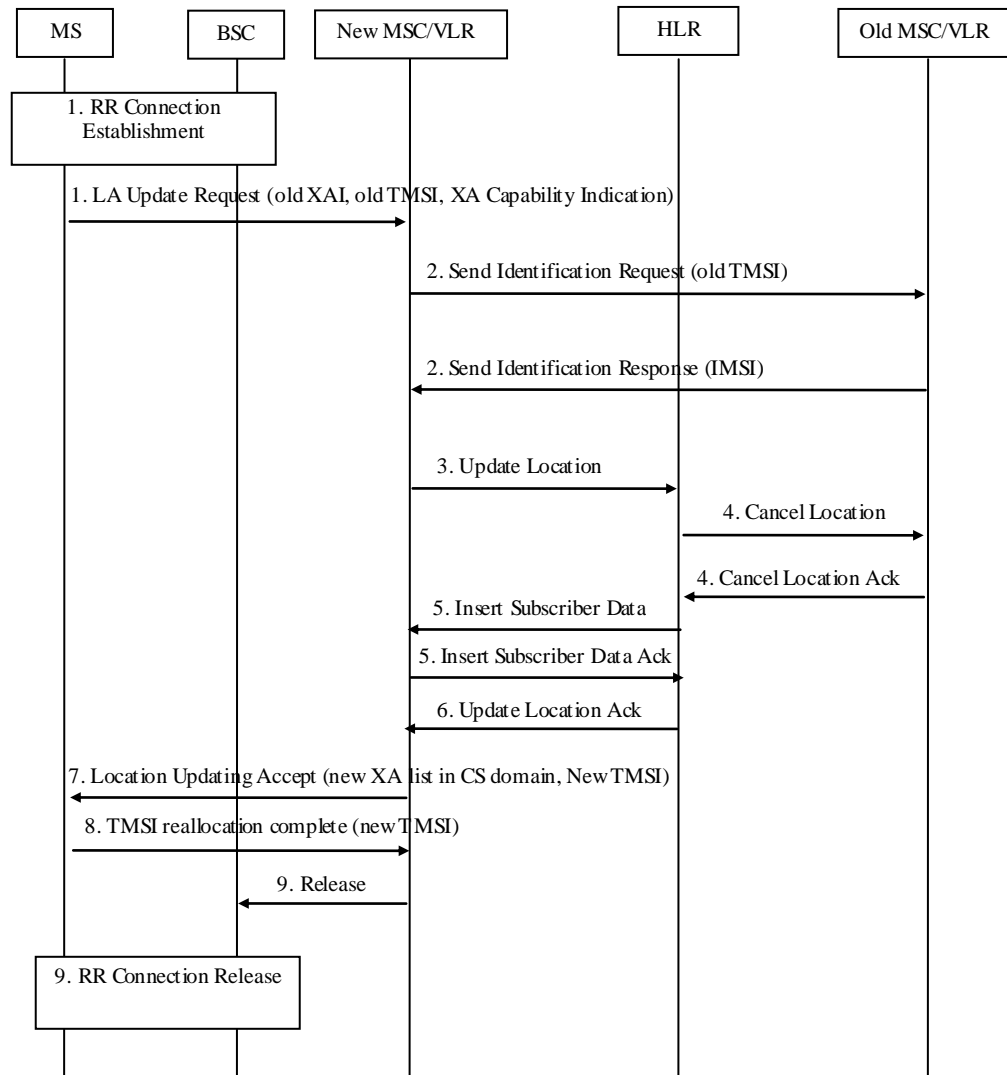
   The RAN shall add LAC and RAC and XAC of the cell where the message was received before passing the message to the MSC.

2. The new 3G_MSC/VLR sends an Send Identification Request (old TMSI) to the old 3G_MSC/VLR to get the IMSI for the UE. (The old LAI received from UE is used to derive the old 3G_MSC/VLR identity/address.) The old 3G_MSC/VLR responds with Send Identification Ack. (IMSI and Authentication triplets).

3. Security functions may be executed.

4. The new 3G_MSC/VLR inform the HLR of the change of 3G_MSC/VLR by sending Update Location (IMSI, MSC address, VLR number) to the HLR.

5. The HLR cancels the context in the old 3G_MSC/VLR by sending Cancel Location (IMSI). The old 3G_MSC/VLR removes the context and acknowledges with Cancel Location Ack.

6. The HLR sends Insert Subscriber Data (IMSI, subscription data) to the new 3G_MSC/VLR. The new 3G_MSC/VLR acknowledges with Insert Subscriber Data Ack.

7. The HLR acknowledges the Update Location by sending Update Location Ack. to the new 3G_MSC/VLR.

8. The new 3G_MSC/VLR validates the UE presence in the new XA. If due to regional, national or international restrictions the UE is not allowed to attach in the XA or subscription checking fails, then the new 3G_MSC/VLR rejects the LA update with an appropriate cause. The new 3G_MSC/VLR includes a new XA list for CS domain in the LA Update Accept. If all checks are successful, then the new 3G_MSC/VLR responds to the UE with LA Update Accept (new TMSI, new XA list).

9. The UE acknowledges the new TMSI with a TMSI reallocation Complete. (TMSI can optionally be reallocated with the TMSI reallocation procedure).

10. When the location registration procedure is finished, the 3G_MSC/VLR can release the signalling connection towards the SRNS for the concerned UE. The SRNS shall then release the RRC connection if there is no signalling connection between 3G_SGSN and SRNS for the UE.

6.1.2.1.1.2   Location Area update with XA concept (A/Gb Mode)

The illustrated transfer of MM signalling to/from the UE uses an established RR connection. For each indicated MM message sent in this case to/from UE, the CN discriminator indicates MSC/VLR.

Figure 6.1.2.1.1.2: Information transfer for location update with XA when changing VLR area (A/Gb Mode)

1 The RR connection is established, if not already done. The UE sends the LA Update Request (old TMSI, old XAI, and XA capability indication, etc.) to the new MSC/VLR. The old TMSI and XAI are those that were assigned to the UE, and XA capability indicates that the UE is XA concept capable. The BSC transfers the message to the MSC/VLR

The RAN shall add LAC and RAC and XAC of the cell where the message was received before passing the message to the MSC.

2. The new MSC/VLR sends an Send Identification Request (old TMSI) to the old MSC/VLR to get the IMSI for the UE. (The old XAI received from UE is used to derive the old MSC/VLR identity/address.) The old MSC/VLR responds with Send Identification Response (IMSI).

3. The new MSC/VLR inform the HLR of the change of MSC/VLR by sending Update Location (IMSI, MSC address, VLR number) to the HLR.

4. The HLR cancels the context in the old MSC/VLR by sending Cancel Location (IMSI). The old MSC/VLR removes the context and acknowledges with Cancel Location Ack.

5. The HLR sends Insert Subscriber Data (IMSI, subscription data) to the new MSC/VLR. The new MSC/VLR acknowledges with Insert Subscriber Data Ack.

6. The HLR acknowledges the Update Location by sending Update Location Ack. to the new MSC/VLR.

7. The new MSC/VLR validates the UE presence in the new XA. If due to regional, national or international restrictions the UE is not allowed to attach in the XA or subscription checking fails, then the new MSC/VLR rejects the LA update with an appropriate cause. The new MSC/VLR includes a new XA list for CS domain in the LA Update Accept. If all checks are successful, then the new MSC/VLR responds to the UE with LA Update Accept (new TMSI, new XA list).

8. The UE acknowledges the new TMSI with a TMSI reallocation Complete. (TMSI can optionally be reallocated with the TMSI reallocation procedure).

9. When the location registration procedure is finished, the MSC/VLR can release the signalling connection towards the BSC for the concerned UE. The BSC shall then release the RR connection.

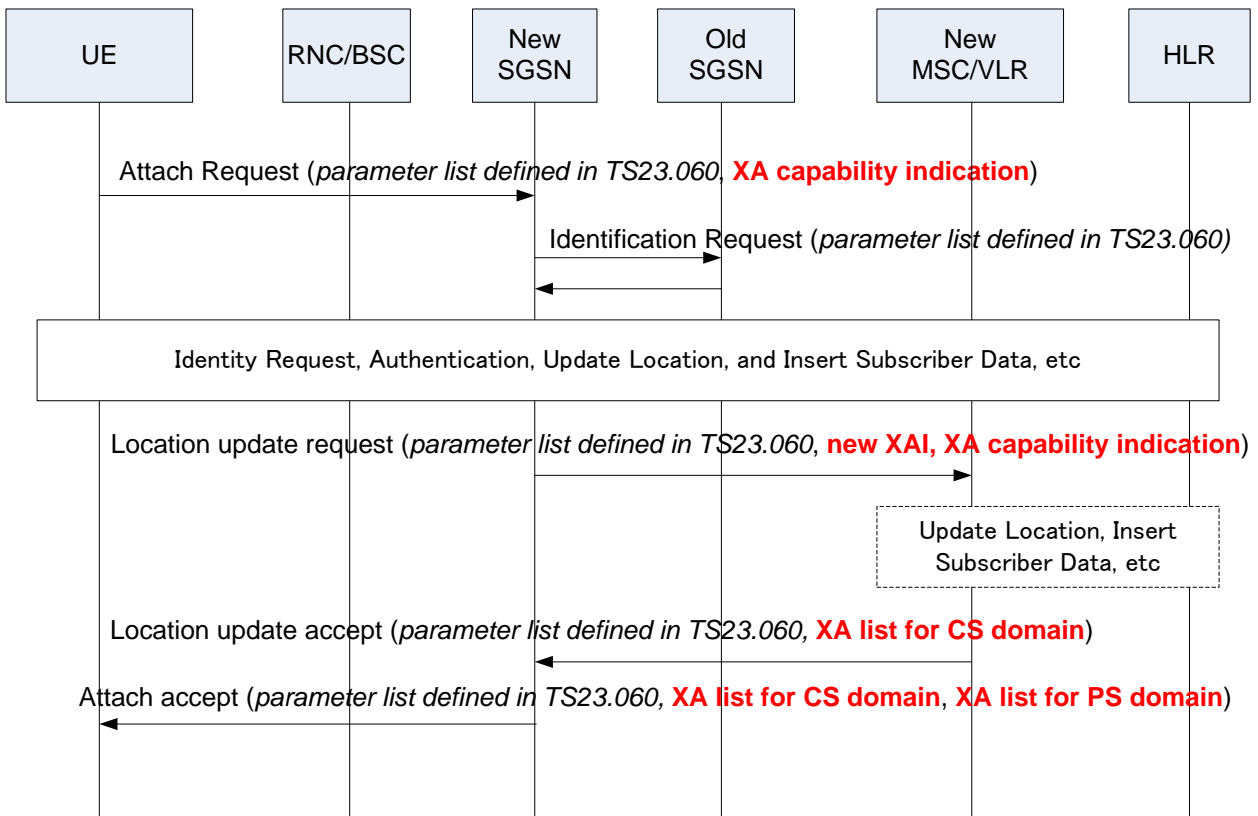## 6.1.2.1.2 Combined GPRS/IMSI attach with XA concept

Figure 6.1.2.1.2: Information transfer for Combined GPRS/IMSI attach with XA when changing VLR area
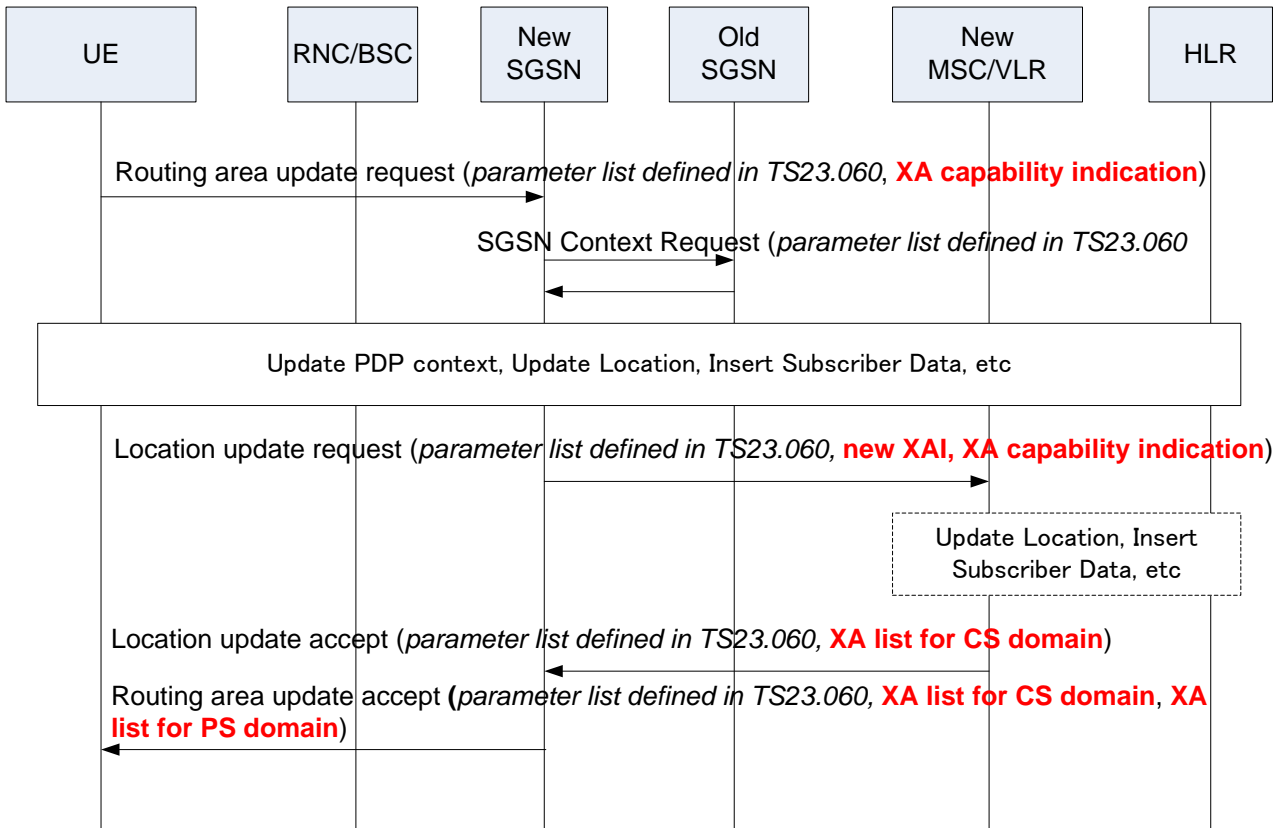
6.1.2.1.3 RA Update Procedure

Figure 6.1.2.1.3: Interface information transfer for routing area update with XA when changing SGSN area

6.1.2.2 Call Control

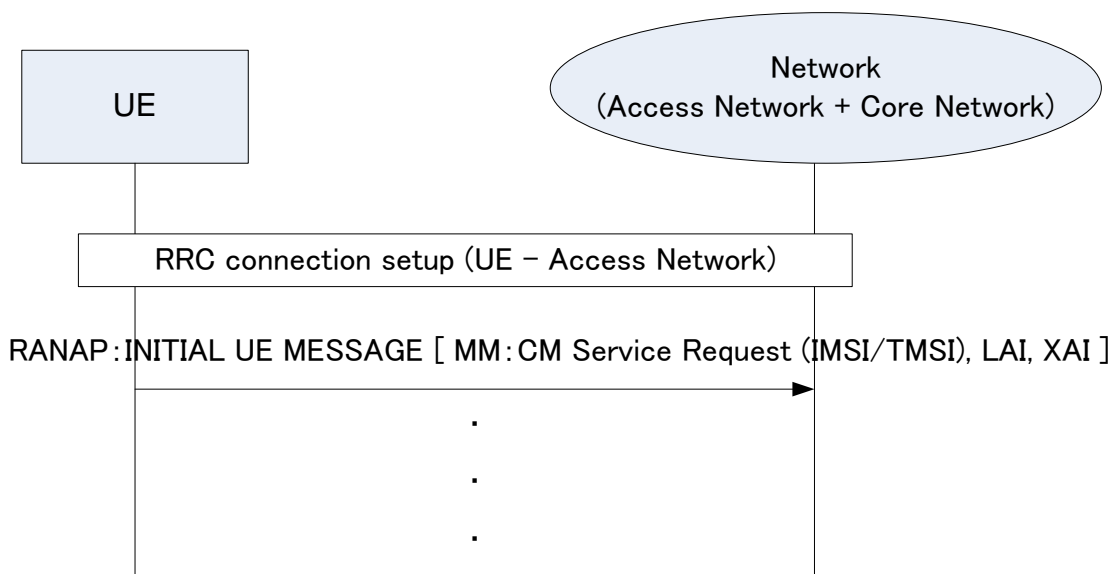### 6.1.2.2.1 Mobile originating call establishment

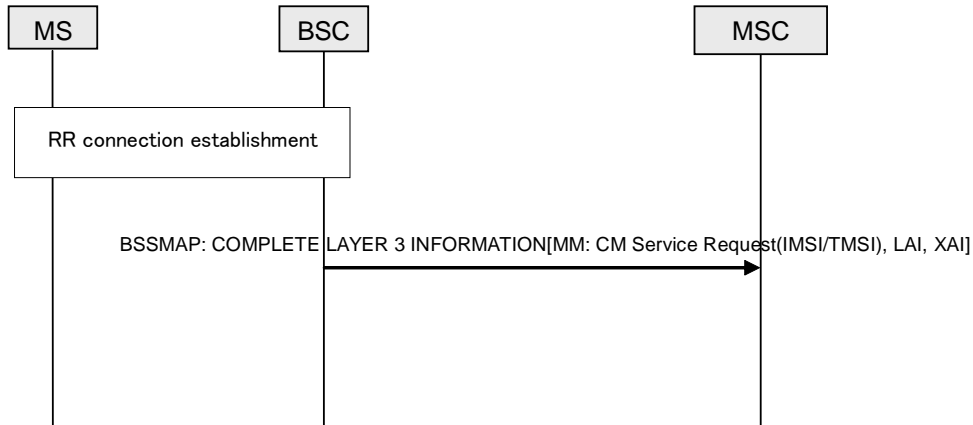**Figure 6.1.2.2.1-1: Mobile originating (Iu mode)**

Figure 6.1.2.2.1-2: Mobile originating (A/Gb mode)

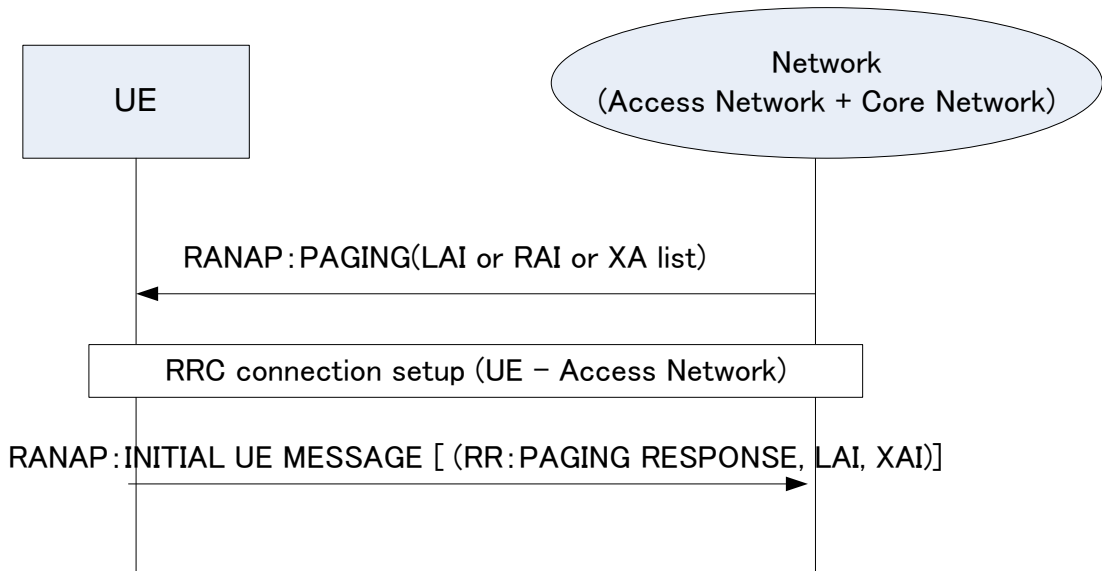6.1.2.2.2 Mobile terminating call establishment

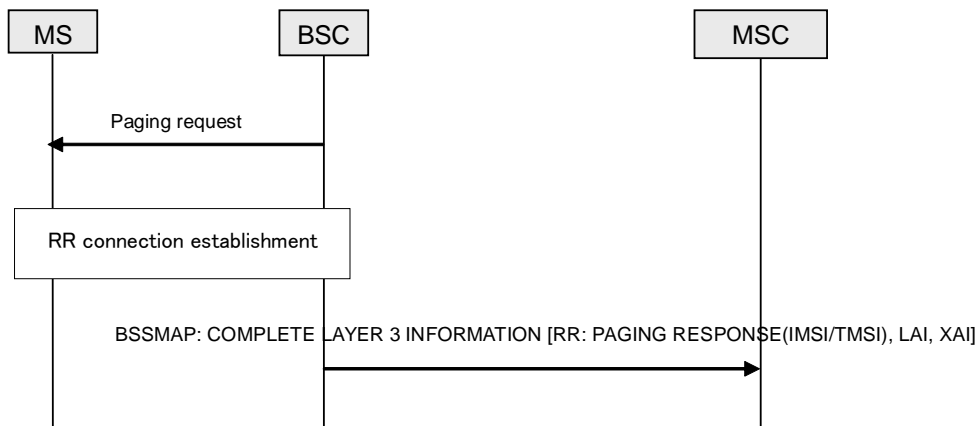**Figure 6.1.2.2.2-1: Mobile terminating (Iu mode)**

Figure 6.1.2.2.2-2: Mobile terminating (A/Gb mode)

6.2 Multiple registration area with current registration area (LA/RA) - Alternative 2

6.2.1 Architectural Details

6.2.1.1 General

The solution assumption is to use multiple registration areas which may be grouped into one list and UE may register that multiple registration areas. Currently, for the mobility functionality five different area concepts are used. LA and RA in the CN as well as UTRAN Registration Area, GERAN Registration Area and Cell areas in the RAN.

This clause presents an architectural alternative with current registration area (LA / RA). Followings are the brief assumption of the solution approach.

- Area concept and requirement and definition of LA/RA are the ones already defined.

- LA/RA can be grouped into each list. Within this grouped area, UE may move around without location update.

- The multiple-LA/RA capable network may respond back with LA list contains multiple location areas and RA list contains routing areas to the location update procedure initiated by UE.

- The multiple-LA/RA capable network pages toward the multiple LA/RAs.

- The UE and SGSN/VLR may require to contain both LA list contains multiple location areas and RA list contains multiple routing areas.

- The LA/RA lists assigned to a UE can be overlapping, i.e. the new LA/RA list assigned to a UE at Routing Area Update/Location Area Update can define a routing area/location area that is overlapping with the area defined by the old LA/RA list.

6.3 Random Delay Solution - Alternative 3

6.3.1 General

The "Random Wait" solution is based on the idea to spread the load on the signalling channels by introducing a random delay timer before the LA/RA signalling is performed.

This random delay could be done by either adding a random time before the actual idle mode cell reselection is performed, or by adding a random time after a new cell has been selected, but before the Updating procedure is started. The later would imply that there could be an increase in the number of page repetitions made in the network while the RAN will page the UE in the old cell during the random time. Note however that a page would only be missed by the UE in the case where a terminating call is incoming during the random waiting time in the UE, the increase in page repetition should thus be minor since the random waiting time should be set to a relatively low value.

If the negative impacts seen from delaying the idle mode cell reselection or the initiation of the Updating procedures are seen as to extensive, it would be possible to initiate the random timer in the UE only at LA/RA boarders. This could be done by e.g. adding information to Broadcast System Information that would instruct the UE to add the random time only at certain cell boarders.

If the risk to lose a page during the random wait time is seen as too big and/or the possible time interval to use for the random time timer is seen as too short, this can be improved by increasing the paging area for a UE to include not only cells within the current LA/RA, but also cells in those neighbouring LAs/RAs to which delayed LAU/RAU can be performed.

Note: The increased paging area can not reach outside an MSC/SGSN pools area.

The method of delaying the Updating procedure with a randomly selected time would imply minor impacts to the UE and optionally minor impacts to the RAN (if additional global pages should be minimized).

Editors Note: Check the existing mechanisms for time dispersion of registration traffic e.g. the 24.008 back off mechanism. It should also be investigated if the existing parameters can be used to achieve similar functionality as the random delay.

6.4 Overlapping Registration Areas - Alternative 4

6.4.1 General

The time that allows UEs to select a new registration area and also the decisions to select a new registration area need to be stretched over a sufficient period of time. This may be reached by sufficient overlap between the registration area and configuration of the selection preferences for the new registration area.

The measurements by the different UEs always slightly differ as there will be different occasions in time when an individual UE detects that the criteria for cell change is fulfilled. The offset values for cell reselection are the same for all UEs, but the measurements differ because of fading, body loss etc...

Thereby UE decisions change the cell and register to new area is not immediate taken with crossing the area border. In addition a selection of the old registration area has to be avoided by appropriate selection criteria to avoid ping pong effects.
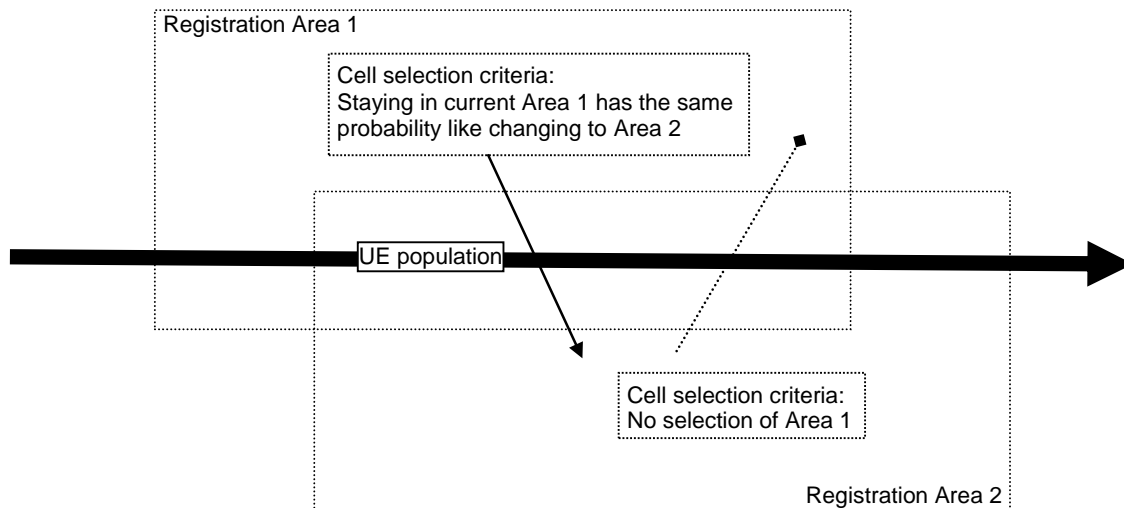
Figure 6.4.1-1: Principle of prolonged unidirectional re-selection

This mechanism is depending on the direction of the movement. This means also that the registration area change can be allocated to different areas for the two directions of movement. This avoids that there is an encounter of two trains with many UEs at the area boundary, which would dramatically worsen the peak load.
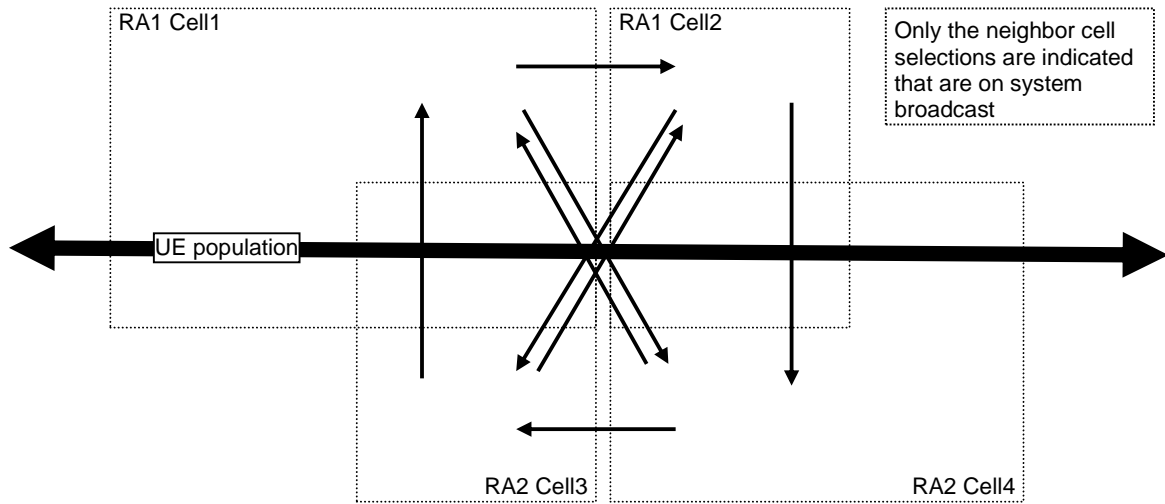
Figure 6.4.1-2: Both directions of the prolonged unidirectional re-selection
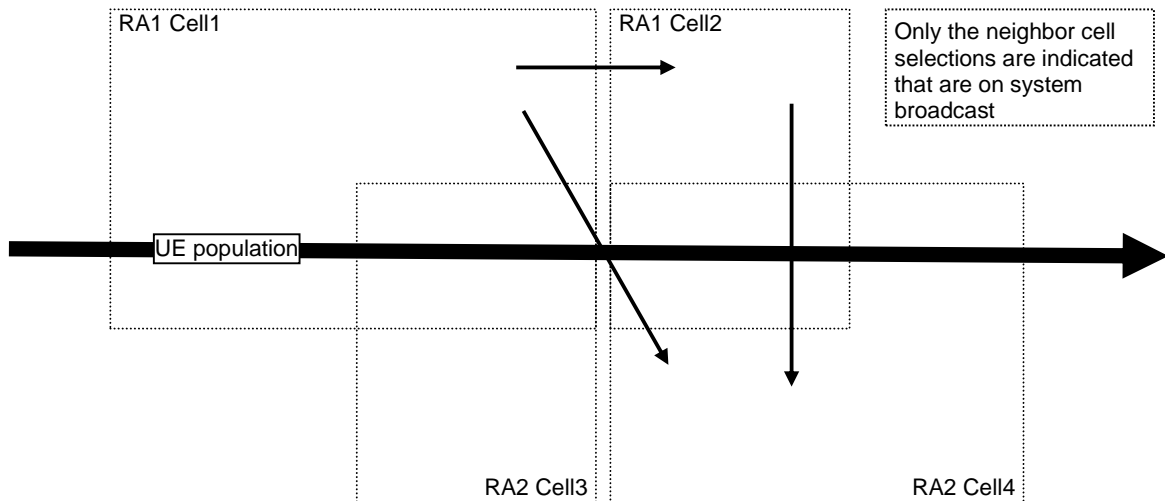

Figure 6.4.1-3: Shows the mechanism for one direction only for better visibility

The UEs in the moving train will preferably select from cell1 to cell2 due to cell1's broadcast parameters. Cell2 and cell4 have sufficient overlap. The selection criteria indicated by cell2 are set in a way that selection of cell4 does not immediately happen as staying in cell2 and quality of cell4 have similar selection probability. Cell4 indicates parameters that avoid selecting back to cell2.

6.5   Improvement to Multiple Registration Areas - Alternative 5

6.5.1   General

Alternatives 1 and 2 have three important drawbacks:

-    The signaling load by registration updates at area borders can only be reduced by a small factor. Factor 2 in a common case, slightly better values only by more complex grouping (longer lists of areas and high complexity if all borders have to get signaling load reduction)

-    Most registration updates are executed on the cells at area borders.

-    The network must distribute UEs in different groups in a pseudo-random way.

These drawbacks can be avoided by introducing the concept of a "center" of the list of registration areas, and the "border" of the registration area. The UE is reachable by the core network in all the areas in the list, but it is only required to issue the registration area **at any time while in a border area**.

This improvement also provides a mechanism to alleviate the problem of increased paging load of alternative 2.

6.5.2   Key Principles

The UE gets a list of registration areas at attach or registration area update and differentiates between center areas and border areas.

- In its simplest form, the area where the attach or area update took place is the center area, any other area in the list is a border area

- In a more complex form, the UE gets a list of tagged areas, allowing for a set of center areas similar to the concept of list of TAs used by EPS to avoid the ping-pong effect

For the Core Network, the UE is reachable in any of the areas in the list. The UE is paged in all those areas. Two alternatives:

- The first page is issued only in center areas. If no response, a second page is sent in center & border areas. Advantage: less paging load. Disadvantage: possible paging delay

- The first page is issued to all areas. Disadvantage: high paging load

While in a "central area" the UE in idle-mode only sends periodic area updates.

While in a "border area" the UE has a random timer set to issue an area update (spread over minutes). Note that this also allows distributing the registration area updates among different cells, including those in the center of the area.

When the UE issues the registration area update, it gets a new list, centered on the current area.

Only if the UE enters in a registration area out of its list, shall it send a registration area update immediately (as in the case without RED).
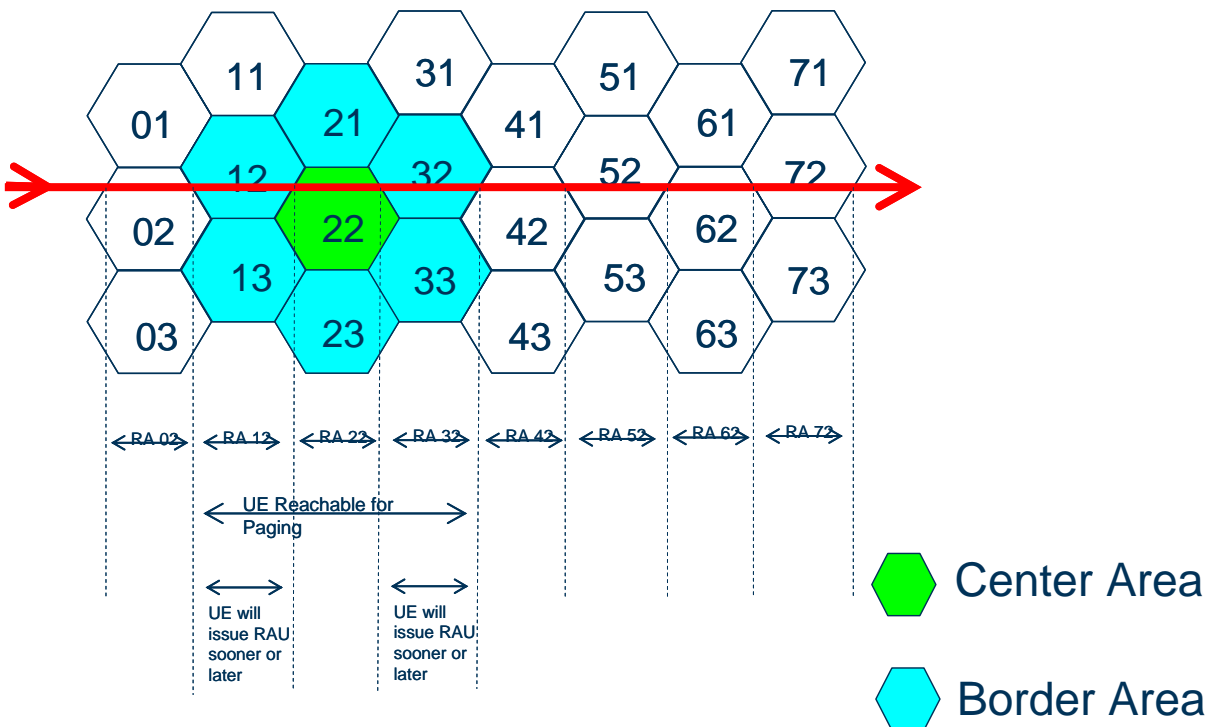

Figure 6.5.2: List of RAs after NAS procedure in RA 22

6.5.3   Considerations about the Random Timer

One key part of the implementation of this improvement is the time that a UE moving from a center area to a border area shall wait before issuing a registration area update.

Although advantages are achieved even by a very primitive implementation of this timer, as long as it is somehow random, it is recommended to use upper and lower bounds for this timer, and to use a uniform distribution.

Recommendations:

-   "T_{min} and T_{max} can be sent by the CN with the list of areas

-   The UE should not issue an area updated before T_{min} after entering the border area (to avoid overlap with legacy UEs)

-   The UE should not wait longer than T_{max}(recommended about 5 to 10 min, but dependent on area size)

-   The UE should use as input the time before its previous area border crossing (so that fast moving UEs get lower a lower maximum timer than T_{max}).
    T_{UE} = factor * time_since_last_area_border_crossing.

-   **Timer** = Random (min(T_{min}, T_{UE}), min(T_{max}, T_{UE}))

6.5.4   Further Considerations

Although the most simple example of list of registration areas, is that of one center area, and all its neighbours as border areas, it must be noted that this improvement allows much more flexibility.

Several center areas can be configured to avoid the ping-pong effect on area borders, in a similar way as lists of TAs are used by EPS.

Wider sets of border areas, i.e. border areas neighbouring with other border areas and no center area, can be used when the registration areas are small and there are high speed mass transport vehicles crossing them.

Center areas with neighbour registration areas not part of the list might also be configured in order to reduce the paging load in cases where there is little registration area update signaling caused by some area borders.
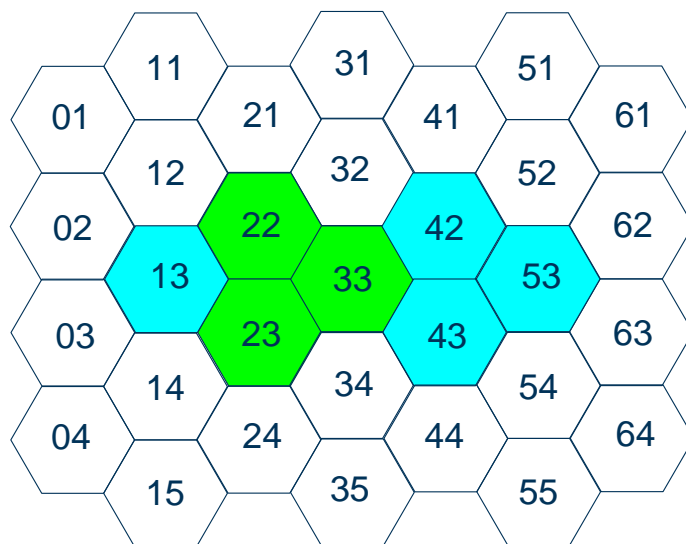

Figure 6.5.4: Example of complex list of registration areas

7 Comparison of Architecture Alternatives

7.1 General

This clause performs analysis on the feasible solution of introducing new registration area (XA) and using current registration area (LA/RA) in terms of operational impact and system impact.

7.2 Impact Comparison

TBD

8 Conclusion

Annex A (Informative):
List of Change Requests

A.1 Change Requests to SA2 WG responsible specifications

NOTE: The following is a list of CRs believed to be required for Alternative 1

Title	Spec No (SA2)	Change Digest	Corresponding documents
Architecture Requirement	TS23.221	- Enhancement on basic MM concept, area concept - Enhancement on identification requirement	S2-07xxxx_CR to TS23.221_Architecture Requirement
GPRS Architecture Requirement	TS23.060	- Enhancement on MM state and timer - Enhancement on SGSN and MSC/VLR interaction	S2-07xxxx_CR to TS23.060_GPRS Architecture Requirement
Network Architecture	TS23.002	- Enhancement on UMTS registration area definition	S2-07xxxx_CR to TS23.002_Network Architecture
Function	TS23.221	- Enhancement on basic MM concept, area concept - Enhancement on identification requirement	S2-07xxxx_CR to TS23.221_functionality
GPRS specific function	TS23.060	- Enhancement on location management procedure - Enhancement on service request procedure	S2-07xxxx_CR to TS23.060_GPRS Mobility Management Functionality S2-07xxxx_CR to TS23.060_GPRS Radio Resource Functionality S2-07xxxx_CR to TS23.060_GPRS Information Storage S2-07xxxx_CR to TS23.060_GPRS Identities_Operational Aspects S2-07xxxx_CR to TS23.060_GPRS Interactions with Other Services
Impact on Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes	TS23.236	- Enhancement on location management procedure within pool area	S2-07xxxx_CR to TS23.236_Functionality S2-07xxxx_CR to TS23.236_Specific Example

A.2 Future Change Requests to other specification

Annex B (informative): Change history

Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2007-10					First draft of TR – creation of version 0.0.1 at TSG SA2#60 (S2-074683, S2-074684)	-	0.0.1
					Addition of Alternative 3 "Random Delay Solution"(S2-074686) in TSG SA2#60	0.0.1	0.1.0
2008-03					Output TR from TSG SA2#63, including addition of Alternative 4 and 5 (S2-081278, S2-081280, S2-081320, S2-081760, S2-081761, S2-081762).	0.1.0	0.2.0