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Agenda Item: **7.2.3**

This version incorporates all the S2 achievements for TS 23.236 “Intra Domain connection of RAN nodes to Multiple CN nodes”, up to and including SA2#18 in Puerto Rico, USA (May 2001).

SA2 now judges the TS is 50% stable and then presents it TSG SA #12 in version 1.0.0.

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Technical Specification

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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

Contents

Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

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

Introduction

UMTS will build on the success of GSM and is likely to become even more widespread, increasing the importance of a flexible network structure which the different operational configurations in which these networks will be deployed. The requirements to have a RNC or BSC controlled by a single MSC server or SGSN lead to certain limitations. Allowing the BSCs and RNCs to connect to a number of MSC servers or SGSNs increases the networks performance in terms of scalability, distributing the network load amongst the serving entities, and reducing the required signalling as the user roams.

Editors Note: It should consider whether this section add any value, or whether it should be removed.

1 Scope

This document covers the details for the intra domain connection of RAN nodes to Multiple core network nodes for GSM and UMTS systems. In particular, it details the impacts to GSM and UMTS systems and the stage 2 procedures for the support of connecting a RNC or BSC to multiple MSC servers or SGSNs. The overall solution is described, and the detailed impacts on the existing specifications is identified.

The reference model to which these procedures apply can be found within 3G TS 23.002 [1]. Detailed architectural requirements within the subsystems are contained within the remainder of the 23 series of specifications e.g. the requirements for the Packet Switched (PS) domain are contained within 3G TS 23.060 [2] and the requirements for the Bearer Independent CS Core Network are contained in 3G TS 23.205[14].

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.

This specification may contain references to pre-Release-4 GSM specifications. These references shall be taken to refer to the Release 5 version where that version exists. Conversion from the pre-Release-4 number to the Release 4 (onwards) number is given in subclause 6.1 of 3GPP TR 41.001.

[1] 3GPP TS 23.002: "Network Architecture".

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

[3] 3GPP TS 23.012: “ Location management procedures”

[5] 3GPP TS 25.331: “ Radio Resource Control (RRC) Protocol Specification”

[6] 3G TS 25.301: “Radio interface protocol architecture”

[7] 3G TS 25.303: “UE functions and inter-layer procedures in connected mode”

[8] 3GPP TR 21.905: "3G Vocabulary".

[9] 3GPP TS 25.413: “ UTRAN Iu interface RANAP signalling”

[10] 3GPP TS 25.410: “ UTRAN Iu Interface: General Aspects and Principles”

[11] 3G TS 23.228 “IP Multimedia Subsystem – Stage 2”

[12] GERAN Stage 2

[13] 3G TS 23.153 ,"Out of Band Transcoder Control - Stage 2".

[14] 3G TS 23.205, “Bearer Independent CS Core Network – Stage 2”

[15] 3G TR 25.931: “ UTRAN Functions, examples on signalling procedures”

Editors Note: A formal review of the references is required.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms defined in 3GPP TR 21.905 [8] apply:

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

Network Using intra domain NAS node selection:	A UMTS or GSM network in which the Intra domain NAS node selection mechanism is being used
NAS node selection Function:	The function used to assign specific network resources (i.e. MSC/VLR server and/or SGSN) to serve a mobile station and subsequently route the control plane traffic to the associated network resource.
Network Resource Identifier	A specific parameter used to identify the core network resource assigned to serve a mobile station.
Pool-area:	A pool area is an area within which a UE may roam without need to change the serving CN element. A pool area is served by one or more core network elements in parallel. All the cells controlled by a RNC or BSC belong to the same one [or more] pool area[s].

Editors Note: Copied from nnsf_clean_001. A review of this section is required.

3.2 Symbols

Editor's note: Not revised in this draft.

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

3.3 Abbreviations

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

BSC	Base Station Controller
CN	Core Network
CS	Circuit Switched
CS-MGW	Circuit Switched Media Gateway
LA	Location Area
MSC	Mobile Switching Centre
NRI	Network Resource Identifier
PS	Packet Switched
RA	Routing Area
RNC	Radio Network Controller
SGW	Signalling gateway
SRNS	Serving Radio Network Subsystem
TMSI	Temporary Mobile Station Identity
UE	User Equipment

Editors Note: A review of this section is required.

4 General Description

Editors Note: This clause should contain a general description of the solution for the intra domain node connection of RAN nodes to Multiple CN nodes. If more than one solution is being studied, this clause will detail all solutions being studied.

4.1 Iu Flex Technical Requirements

This provides a (non-exhaustive) set of technical requirements:

1. IuFlex capable RAN nodes such as the RNC/BSC should be able to select any CN node such as the SGSN/MSC-Server within a pool area
2. IuFlex capable RAN nodes and CN nodes should be able to co-exist with pre release-5 RAN nodes and pre release-5 CN nodes..
3. The network should provide the CN node routing information to the UE and the UE should store it.
4. During the initial non-access stratum signalling, the UE should provide to the RAN node the routing information for the current serving CN.
5. The solution should not preclude the support of multiple core networks (from different PLMNs/operators) connected to a single RNS or BSS.
6. The solution shall enable the reduction of signalling within the core network (e.g reduction of the HLR signalling traffic).
7. The solution shall enable an improved scaling between radio access nodes and the core network nodes.

4.2 General description

Note: Clarification is required in order to remove RAN nodes and CN node terminology and to capture that this is referring to the control signalling aspects.

The Intra Domain Connection of RAN Nodes to Multiple CN Nodes does …..

The purpose of connecting RNCs and BSC nodes to multiple MSC/SGSN nodes (“Iu, A & Gb flexibility”) is to increase service availability, reduce signalling traffic in the CN, achieve load balancing within certain CN areas and support easier CN capacity expansion. Within a pool-area a number of CN nodes is grouped together to a server-pool. All the nodes of a domain (CS/PS) in such a pool-area share the responsibility for handling all Ues' in the pool-area. So each UE in the pool-area may potentially be served by any MSC/SGSN of the pool area. Figure 1 below shows the principles of a Core Network with pool areas (Only the parts relevant for this report are shown).

The idea behind core network element pooling is to handle a UE in one dedicated CN element of a domain as long as it is in radio coverage of the pool-area. Therefore the CN nodes have to share the responsibility for all location areas (LAs) and routing areas (RAs) of the whole pool-area, meaning that every MSC and SGSN can handle UEs in all LAs and RAs of the pool-area. This leads to a significant reduction of signalling traffic in the CN since e.g. external location updates, SGSN relocation and inter-MSC handover procedures become obsolete to a large extend.

The mechanism to keep a UE in one dedicated server is the provisioning of a Network Resource Identifier (NRI) to the UE by the serving CN node. This NRI is provided to RNC by the UE with each new UE-CN signalling connection establishment. In the RNC it is analysed and the request is forwarded to the responsible node in the CN. To make efficient routing decisions in the RNC this requires that the UE be enabled to indicate whether it has newly roamed in the pool-area, or whether it has been server by this pool-area before.

Editor's note: For GSM MS the need for a default CN element is for further study.

4.3 Network Structure

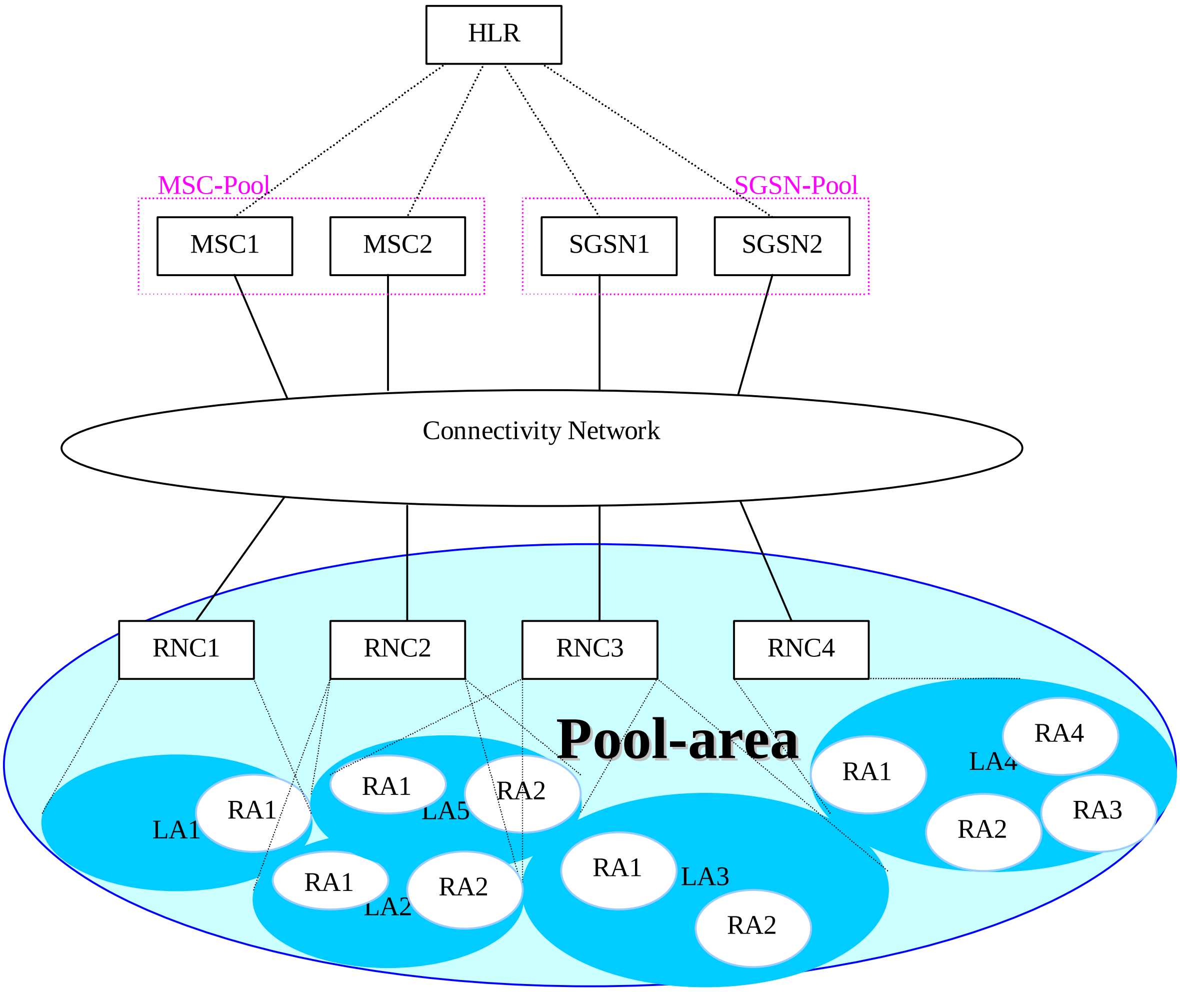


Figure 1: Structure of a Core Network with pool areas

Note: [Iu-Flex] does not have impact on the configuration options of the location areas and routing areas with the RAN.

Note. Clarifications are required to figure 1 to e.g. remove that LAs do not

Note. This must be further described

4.4 Network Node identification

A CN element in a pool area is identified by the Network Resource Identifier (NRI).

Connecting a RAN node to multiple CN nodes requires a new routing functionality ("NAS node selection function") within the RNC nodes. The routing function entity in the RNC analyses the access stratum part of the RRC-Initial-direct-transfer message from UE. Based on the information in the intra domain NAS node selector (IDNNS), and the CN-domain indicator the routing decision in the RNC is taken. The information in the IDNNS has to be provided by the NAS entity in the UE.

If the UE is new in the pool-area, then the RNC will select a CN element according to the distribution algorithm in the NAS node selection function. After receiving the request the serving CN element will assign a new TMSI or P-TMSI to the UE.

If the UE has already been served by this pool-area at the previous CN access then the request is routed to the same CN node as the request(s) before.

4.5 Pool identification

The NRI identifies CN elements within the pool-area. The UE gets the NRI of its serving CN element as part of the TMSI. The UE includes the NRI derived from its current TMSI in any initial NAS signalling message. The RNC establishes a signalling connection the CN element identified by the NRI regardless whether this NRI is derived from a TMSI allocated by this CN element or by another. If the RNC has no CN element configured for the NRI the RNC selects an available CN element and establishes the signalling connection with this CN element.
There are no functionality in the Ue to discover the pool area change – the pool area change is detected in the network.

Some examples describe potential applications.

Network configuration example 1

This example configures 9 pool-areas each with 3 CN elements serving within a pool-area. When a UE moves from one (NRI:1,2,3) to another pool-area (NRI:4,5,6). It indicates the old NRI (3) derived from its old TMSI to the RNC in the new pool-area (NRI:4,5,6). This NRI 3 is not configured in the RNC of the pool-area (NRI:4,5,6). The RNC selects a CN element out of the available NRIs 4,5,6 and establishes the signalling connection for the UE with the selected CN element. This new CN elements allocates a new TMSI to the UE and thereby the new NRI for the new pool-area.

In this example, the NRIs can be re-used in a pattern where adjacent pool areas do not use the same NRI. Every pool area change will initiate a new selection of a new core network node.

19, 20, 21	22, 23, 24	25, 26, 27
16, 17, 18	1, 2, 3	4, 5, 6
13, 14, 15	10, 11, 12	7, 8, 9

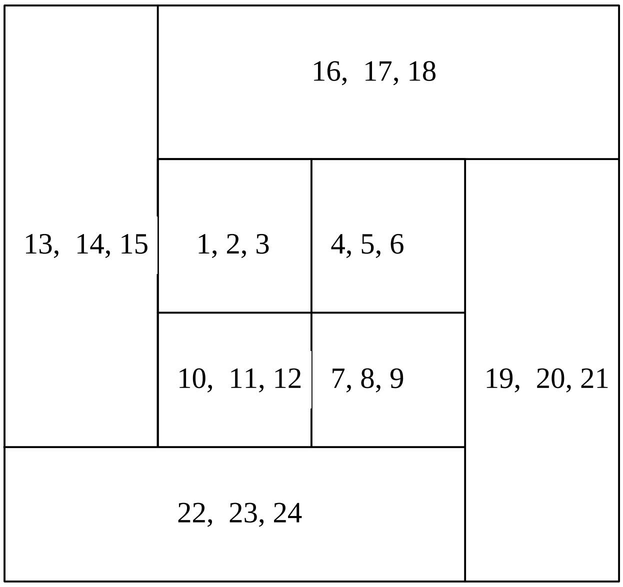
Network configuration example 2

In this example one RAN serves two core networks. For this purpose the NRI space is divided between the core network. The example configures only one node per core network node within a pool-area. After the initial assignment to a core network every UE is assigned again to CN elements of the same core network when the pool-area is changed. The example corresponds to an overlay of two core networks each without Iu-Flex as per core network only one CN elements serves an pool-area. This configuration can be extended by multiple CN elements serving a pool-area per core network.

1, 2	1, 2	1, 2
1, 2	1, 2	1, 2
1, 2	1, 2	1, 2

Network configuration example 3

In this example overlapping pool-areas are configured by a grouping of sub-pool-areas. A sub-pool-area in the figure is for example the area served by the CN elements with the NRIs 4,5,6. An overlapping pool-area in this example is defined by a sub-pool-area and all its adjacent sub-pool-areas. The pool-area around the sub-pool-area defined by the NRIs 4,5,6 is the pool-area with the NRIs 1,2,3,4,5,6,7,8,9,10,11,12,16,17,18,19,20,21. A UE is assigned to this pool-area if a new NRI/CN element has to be assigned the UE and it is located in the sub-pool-area with NRIs 4,5,6. The RNCs of this sub-pool-area are configured to select only from the NRIs 4,5,6 of this sub-pool-area. After this assignment to a CN element according to the NRIs of the sub-pool-area the UE may roam within the pool-area defined by the 18 NRIs listed above without changing the CN element. For this purpose all RNCs have to be configured to route the NRIs of their adjacent sub-pool-areas. But no RNC selects an NRI of an adjacent sub-pool-area for assigning a UE to a CN element. When the UE leaves the pool-area the new RNC will not know the old NRI and selects a new CN element out of its sub-pool-area.



4.6 Structure of Intra Domain NAS Node Selector (IDNNS)

The NAS node selection function in the UTRAN selects the CN-element within a specific domain according to information provided by the NAS application in the UE. This information is provided to the UTRAN in the AS part of the RRC-Initial-direct-transfer message. This part is called the Intra-Domain-NAS-node-selector (IDNNS).

The IDNNS provides sufficient information to the network to determine whether the mobile is new to the pool area (note that the means to do this is dependant upon the alternative for detecting the pool area change). When the mobile is known in the pool area, the NRI information of the IDNNS contains sufficient information to route the signalling to the correct MSC/SGSN.

4.7 Support of combined mobility management procedures

There are three alternatives identified for the support of the combined mobility management procedures (Gs interface). This section captures the alternatives for evaluations.

For every alternative, the SGSN shall provide the functionality to select the serving MSC in the CS domain of the pool area. This is the similar functional to the functionality which resides in the RNC for selecting the MSC server/SGSN in the pool area.

For every alternative, the SGSN shall store the subscriber's VLR identifier for the selected MSC.

4.7.1 Alternative 1

Attach

In case of 'combined GPRS/IMSI attach' or 'GPRS attach when already IMSI attached', the SGSN sends the Location Update Request message to the MSC/VLR. The UE sends NRI indicating the MSC/VLR in the Attach Request message to the SGSN if the pool area has not changed. If NRI indicating the MSC/VLR is sent by the UE, the SGSN selects the MSC/VLR based on the pool and NRI. If the SGSN does not receive NRI indicating the MSC/VLR, it selects any MSC/VLR from the pool.

The SGSN stores the MSC/VLR id as in R99 Gs interface support.

Routing area update

Within a pool area, the SGSN and the MSC/VLR are not changed.

If the pool area changes, the new SGSN selects any MSC/VLR from the new pool.

4.7.2 Alternative 2

Attach

If attach type is 'combined GPRS/IMSI attach' then the SGSN first fetches subscriber data from HLR and if the UE is already IMSI attached then the serving VLR-id should be received during insert-subscriber data procedure from HLR. If no valid VLR-id is received or the VLR-id belongs to another pool-area then any MSC/VLR of the own pool-area may be selected by SGSN. In case the connected MSC doesn't belong to a MSC pool and no valid VLR-id is available then the SGSN may use the LAI to determine the MSC.

If SGSN receives attach type 'GPRS attach with already IMSI attached' then the serving VLR-id should be received during insert-subscriber data procedure from HLR. If the VLR-id is not received, the SGSN can choose any MSC within the MSC pool. If the connected MSC doesn't belong to a MSC pool and no valid VLR-id is available then the SGSN may use the LAI to determine to MSC.

In case attach type is 'GPRS only' then the VLR-id may be received during insert-subscriber data procedure. In this case it should be stored in the subscriber data for potential later usage if it belongs to the MSC pool of this area.

Routing area update

In case of a combined LA/RA update procedure with attach type 'combined RA/LA update with IMSI attach' or 'combined RA/LA updating' and if the UE was GPRS attached already, then the SGSN shall use the VLR-id stored in the UEs subscriber data to determine the associated MSC/VLR of the MSC pool. If the VLR-id is not received, the SGSN can choose any MSC within the MSC pool. If the connected MSC doesn't belong to a MSC pool and no valid VLR-id is available then the SGSN may use the LAI to determine the MSC.

4.7.3 Alternative 3

Attach

In case of 'combined GPRS/IMSI attach' or 'GPRS attach when already IMSI attached', the SGSN sends the Location Update Request message to the MSC/VLR. The SGSN selects any MSC/VLR from the pool.

Routing area update

Within the pool area, the SGSN and the MSC/VLR are not changed.

If the pool area changes, the new SGSN selects any MSC/VLR from the new pool.

4.7.4 Comparison

Alternative 1 requires changes to 24.008 signalling.

Alternative 2 requires changes to MAP signalling and requires HLR updates in other PLMNs

Alternative 3 requires further evaluation

5 Functional Description

Editors Note: This clause describes the more detailed aspects of the functioning of the connection of RAN nodes to multiple CN nodes. If more than one solution is being studied, this clause will detail all solutions being studied.

5.1 UE Functions

The UMTS UE is expected to provide the IDNNS to the RNC in the access stratum part of the *RRC_initial_DT* message. Specifically it should provide the NRI and the PA-changed indicator of the IDNNS to the RNC.

No changes are expected in the GSM MS.

5.2 RNC Functions

The RNC masks the significant number of bits out of the NRI provided by the UE in the initial NAS signalling message. The significant number of bits is configured in the RNC.

The RNC shall route the request in the NAS-PDU according to the IDNNS and the 'domain indicator' (CS or PS) to the Core Network.

The RNC routes initial NAS signalling messages according to the NRI and the "domain indicator" (CS or PS) to the relevant core network node if a core network node address is configured in the RNC for the specific NRI and the requested domain (CS or PS).

If no core network node address is configured in the RNC for the requested NRI and domain (CS or PS) then the RNC routes the initial NAS signalling message to a core network node selected from the available core network nodes which serve the domain (CS or PS). The selection mechanism is implementation dependent.

5.3 BSC Functions

5.3.1 A interface

The BSS is aware whenever a new RR connection is established. In particular, the BSS always examines the content of the Initial Layer 3 message sent by the mobile in order to determine the position of the MS Classmark and to extract its contents. Examination of the Initial Layer 3 message contents allows the BSS to observe the TMSI+LAI or IMSI or IMEI.

In Location Update Request messages, analysis of the NRI bits in the TMSI and, possibly, the PLMN ID in the LAI, allows the BSS to determine whether or not the mobile is a new entrant to the pool. If the mobile is a new entrant, then the BSS selects an MSC from the pool area to use. If the mobile is not a new entrant, then the BSS uses the NRI bits in the TMSI to select the registered MSC.

For Initial Layer 3 messages other than Location Update Requests, the BSS uses the NRI bits in the TMSI to route to the registered MSC. For SIM-less emergency calls, the BSS selects an arbitrary (but not overloaded) MSC.

The BSS is configured (by O+M) so that it knows which bits in the TMSI are to be used as the NRI bits.

5.3.2 Gb interface

FFS.

5.3.3. Iu interface

FFS.

5.4 MSC Functions

In every MSC an address of the MSC within the CS domain pool is configured. This address has a flexible length (between zero bits and the length of the NRI). The TMSI allocation function in the MSC indicates this MSC address within the TMSI part which is reserved for the NRI. The use of the bits not needed for this MSC address within the NRI space is implementation dependent.

The MSC provides the NRI to the UE. It is encoded as a subfield of the TMSI.

If a MSC has to address the old MSC where the UE was previously attached the old MSC can be found using the LAI and the NRI.

Note: on the VLR-VLR interface, the mobile is identified by the TMSI, and not the TMSI + LAI. It may be required to also include the LAI on this interface to increase the range of available TMSIs.

5.5 Functions in SGSN

In every SGSN an address of the SGSN within the PS domain pool is configured. This address has a flexible length (between zero bits and the length of the NRI). The P-TMSI allocation function in the SGSN indicates this SGSN address within the P-TMSI part, which is reserved for the NRI. The use of the bits not needed for this SGSN address within the NRI space is implementation dependent.

The SGSN provides the NRI to the UE. It is encoded as a subfield of the P-TMSI.

If the new SGSN has to address the old SGSN where the UE was previously attached (e.g. in case of attach or Identification Request) the old SGSN can be found using the RAI and the NRI.

Editor Note: Verification of whether GTP for the transports RAI.

6 Specific Examples

Editors Note: This clause describes some examples of the application of the a network using the intra domain NAS node selection

7 Benefits and Drawbacks

Editor's note: This clause will include some of the benefits and drawbacks of the functionality. If more than one approach is being studied, some comparison will be included in this clause.

7.1 Advantages

7.2 Disadvantages

8 Impact on UMTS specifications

Editor's note: This is a clause will capture the impacts required on the existing specification in order to support the required functionality.

Annex A (informative): Conclusions and Open Issues

Editor's note: This annex is regarded as a temporary annex which will be removed before publication.

A.1 Initial Conclusions

The following are some agreements captured in the ongoing work, which have not found a place in the main body of the document yet.

a) This is expected to be a new function of existing functional entities, not a new functional entity.

b) The current working assumption is that 'alternative B' will be used. Pool identification alternative A is moved to annex B for information. Also all parts reflecting the 2 alternatives are rephrased.

c) It is an objective that the solution works for UTRAN and GERAN (in both Iu and A/Gb modes).

A.2 Open Issues

The following open issues have been raised in the discussion related to this functionality:

a) It is required to have terminology and concepts to describe the "area" we are referring to when talking about a collection of SGSNs, MSC servers and RNCs.
It is important that the terminology allows a discussion to distinguish between the areas where the concept applies, as well as the scope of the "areas".

b) Means for a CN node to redistribute the load is FFS.

Annex B (informative): Removed alternatives

Editor's note: This annex contains alternatives that have been discussed earlier and have been removed during the drafting meetings.
This annex is regarded as a temporary annex which will be removed before publication.

4.5.1 Alternative A: Pool identification with Pool Area Code

The concept of introducing pools areas in the core network introduces a sub-division of the existing structure of the CN. The new level that is from now on referred to as "*Pool-Area*" (PA) is inserted between PLMN and MSC/SGSN area level. The new identifier "*Pool-Area-Code*" (PAC) is introduced as a sub-structure of the existing LAI/RAI information.

The introduction of the PAC is achieved by splitting-off the Pool-area-Code (PAC) from the (old) Location Area Code (LAC). All the other fields as well as the total length of the LAI/RAI remain unchanged. This concept allows a world-wide unique identification of a pool area. The LAC is then unique within a Pool-area.

Note that the PAC together with the (new) LAC forms the (old) LAC as it was known from previous releases. CN elements and UEs that are not aware of the new structure will thus interpret PAC plus (new) LAC as (old) LAC just as before the introduction of pool-areas.

In case the PAC is used in the LAI/RAI information then the UE is enabled to detect when a pool area border is crossed. The UE will then set the PA-changed indicator in the IDNNS accordingly when requesting access to the CN.

The concept of having the PAC as part of the LAI/RAI implies that there can be no overlapping pool areas for GSM and UMTS. For GERAN this option is ffs since multiple LAI can be broadcast.

In case the PA-changed indicator is set then the NNSF operates in 'selection-mode' and selects the appropriate CN element depending on the load-sharing algorithm.

In case the PA-changed indicator is not set then the NNSF has to operate in routing-mode. In routing mode the NNSF always analyses the NRI provided by the UE.

5.2 RNC Functions

The RNC masks the significant number of bits out of the NRI provided by the UE in the initial NAS signalling message. The significant number of bits is configured in the RNC.

The RNC shall route the request in the NAS-PDU according to the IDNNS and the 'domain indicator' (CS or PS) to the Core Network.

For alternative A,

if the PA-changed-indicator is set to 'new pool' this indicates that the UE has roamed newly to this pool-area. In this case the RNC can select one of the CN elements in the addressed domain.

If the PA-changed-indicator is set to 'old pool' the UE has been served in this pool area with the previous request already. In this case the RNC should route the request according to the NRI.

5.3.1 A interface

The BSS is aware whenever a new RR connection is established. In particular, the BSS always examines the content of the Initial Layer 3 message sent by the mobile in order to determine the position of the MS

Classmark and to extract its contents. Examination of the Initial Layer 3 message contents allows the BSS to observe the TMSI+LAI or IMSI or IMEI.

Alternative A: In Location Update Request messages, analysis of the LAI allows the BSS to determine whether or not the mobile is a new entrant to the pool. If the mobile is a new entrant, then the BSS selects an MSC from the pool area to use. If the mobile is not a new entrant, then the BSS uses the NRI bits in the TMSI to select the registered MSC.

Annex C (informative): Network configuration examples

Editor's note: This annex contains the examples for network configurations that have been discussed during the drafting meetings. All of them are based of pool-identification alternative B.

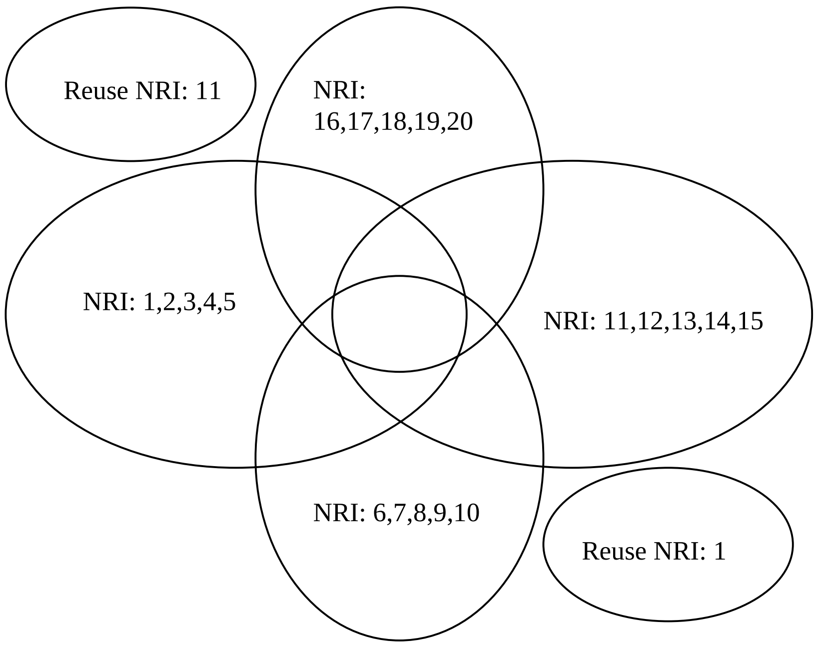
C.1: One city centre surrounded by residential areas

Assumptions:

This example shows a network covering one city centre surrounded by residential areas. The city centre is covered by all 4 pool-areas while the residential areas are covered by one pool-area only. Once a subscriber „found" its pool-area, he will not change the pool-area while commuting between the city centre and his residential area.
Each of the pool-areas is served by 5 MSCs, indicated by the 5 NRI values in the figure below.

The example in the figure configures 4 overlapping pool-areas;

- City centre with 12 Mio subscribers (with context in VLR, attached or detached)
- One switch office/building with 5 MSCs (5 NRIs) per pool-area
- Capacity of one MSC/VLR up to 1 Mio subscribers in VLR
- 4 bits are assumed for the VLR-restart counter
- Only distinct NRI values are used, so a UE changing between pool-areas will always be allocated to a new MSC by the NAS node selection function



TMSI calculation:

For addressing in the CS domain 30 bits for can be used (Bit 30&31 are reserved).

- The assumption is that 4 bits are used for the restart counter.

- To differentiate the 20 MSC in the city area 5 bits are needed for the NRI (12 NRI values remain unused; these 12 NRIs are left for additional MSCs in the whole area, NRIs can also be re-used as indicated in the figure)
- This leaves 30-4-5 = 21 bits for every MSC to address the subscribers data records in the VLR. (This give address space for 2 Mio TMSIs unique over all LAs of the MSC)
- The 4 pool-areas sum up to 20 Mio subscriber, allowing for some unbalanced load distribution

C.2: 3 Neighbouring large city centres

This documents provides some calculations for ‘pool-identification alternative B’ in case that 3 huge city centres are covered by pool-areas with direct contacts.

Assumptions:

The calculations are based on the following assumptions:

- 3 neighbouring pools with capacity of 32 M non-purged subscribers each
- Maximum capacity of a paging channel is 1 M pagings/hour per LA
- 0.25 pagings / hour are assumed per subscriber → 2M TMSI/LA can be realized
- For the ‘VLR-restart’ counters a number of bits need to be reserved. Working assumption is that 5 bit should be sufficient for any implementation, in the examples these 5 bits are reserved on the upper part of the TMSI. (This is of course implementation specific and not part of Iu-Flex.)
- The calculations are based on a node capacity of up to 1M (2^20) non-purged subscribers this results in:
  - o Minimum 32 nodes are needed per pool-area (5-bit NRI)
  - o Minimum is 16 LA’s per pool-area

Basic configuration needed for 1 pool:

- To address the 32M TMSI per pool the total number of 25 bits are needed in the TMSI.
- For a node capacity of 1M non-purged TMSIs 20 Bits have to be reserved for TMSI per NRI and 5 bit for the NRI value.
- The NRI is located bit 14-23 (configurable). It is assumed that the bits 19-23 are used for the NRI.

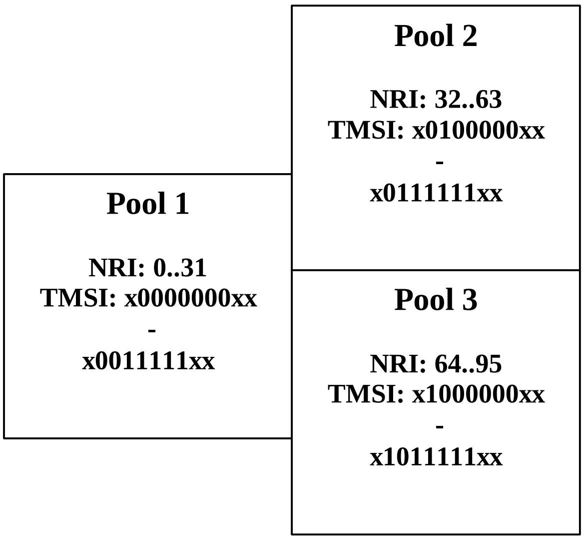
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		‘VLR-restart’						used NRI range																							

Figure 2: Example of a TMSI structure with 5 bit ‘VLR-restart counter’ and 5 bits NRI-length;

‘3 pool configuration’ – no sharing of NRI values:

- This example assumes that the 3 pool-areas have independent NRI values, so the available TMSI range has to be shared between the pools. All TMSI’s from other pool-areas can be detected – best load distribution in the pools.

- So 3*32 = 96 NRI values are needed for all 3 pools. The NRI-length has to be increased to 7 bit. (not an optimum configuration since 32 NRI values are unused). In the example the NRI now uses bits 23-17.
- Since still for each NRI value 20 bits are needed to address 1M TMSIs there is a conflict with the assumed VLR-restart field length of 5 bit. The VLR-restart field has to be reduced to a 3 bit field in order to free sufficient addressing space in the TMSI structure!



NRI: 96..127
TMSI: x1100000xx - x1111111xx
are unused

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		'VLR- restart'						used NRI range																							

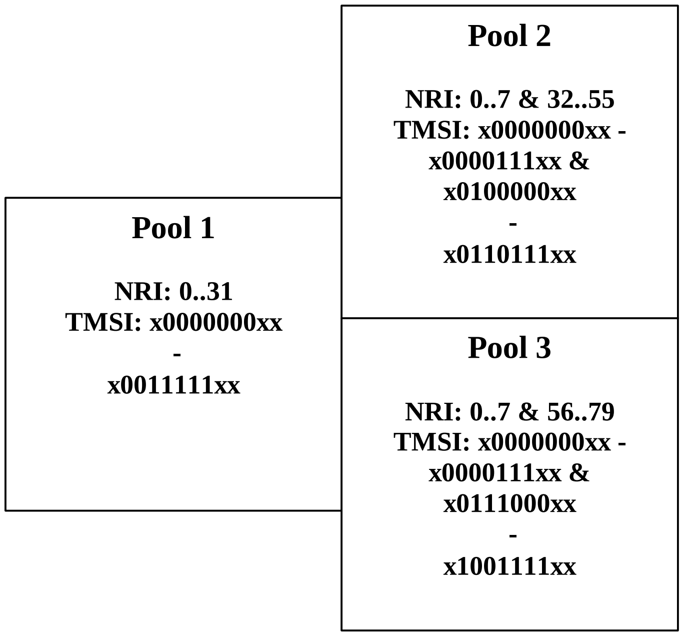
Figure 3: Modified TMSI structure 7 bits NRI-length; VLR-restart field must be reduced to 3 bit.

- In this example configuration 32M TMSI values are wasted! So it would be more efficient to assign these TMSI ranges to the 3 pools rather than leave them unused. Alternatively these values could be used for sharing with nodes in the 'outside world'.
- The major drawback of this solution is the reduction of the VLR-restart field to 3 bit only!

'3 pool configuration' – 25% of NRI values shared between the pools:

- Now the pool configurations are changed in a way that 25% of the NRI values are the same in all the 3 pools. This means that for ¼ of subscribers pool-changes cannot be detected. The traffic generated by these subscribers will not be distributed, but is routed by the NAS node selection function to the specific node with this NRI value in the new pool.
- The total range of needed NRI values is reduced by this to:
  8 (the shared NRI's) + 3 * 24 = 80
- To code this NRI's still 7 bit are needed. So there is no gain in terms of addressing space in this example.

- In the example the NRI values 0..7 are shared and so are the TMSI ranges x0000000xx .. x0000111x



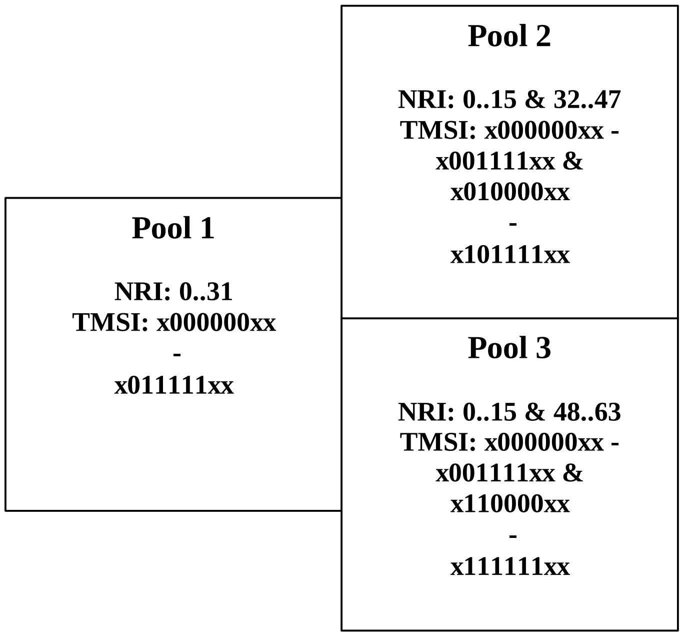
NRI: 80..127
TMSI: x1010000xx - x1111111xx
are unused

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		'VLR-restart'						used NRI range																							

Figure 4: Modified TMSI structure 7 bits NRI-length; VLR-restart field must remain 3 bit.

'3 pool configuration' – 50% of NRI values shared between the pool<u>s:</u>

- The percentage of the shared NRIs is now increased to 50%. So ½ of the NRI values are the same in all the 3 pools. This means that for ½ of subscribers pool-changes cannot be detected. The traffic generated by these subscribers will not be distributed, but is routed by the NAS node selection function to the specific node with this NRI value in the new pool.
- The total range of needed NRI values is reduced by this to:
16 (the shared NRI's) + 3 * 16 = 64
- This reduction of NRI saves 1 bit in NRI length. So the VLR-restart can be slightly increased to 4 bit (still 1 bit less than in the original assumption)
- In the example the NRI values 0..15 are shared and so are the TMSI ranges x000000xx .. x001111x

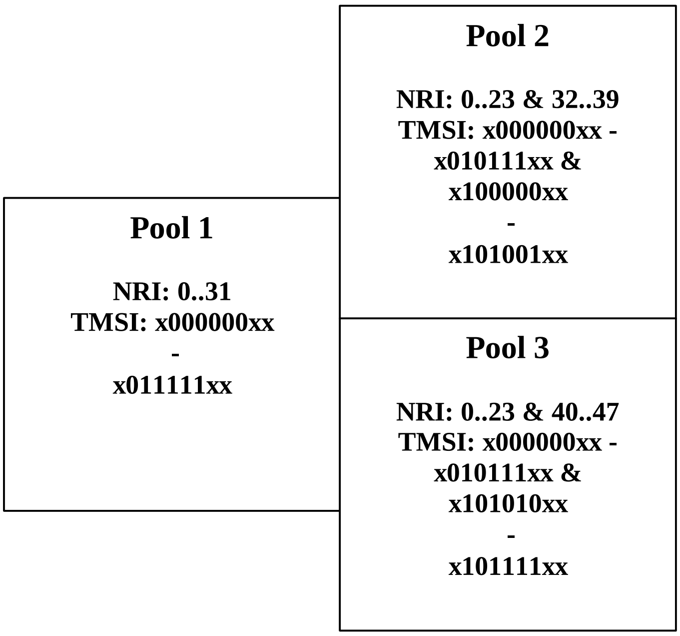


31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		'VLR-restart'						used NRI range																							

Figure 5: NRI-length can be reduced by 1 bit; VLR-restart field can increase to 4 bit.

'3 pool configuration' – 75% of NRI values shared between the pools:

- Next step is to even increase the shared part of the NRI to ¾. This means that only 25% of the incoming traffic in a pool-area is distributed.
- The total range of needed NRI values is reduced by this to:
  24 (the shared NRI's) + 3 * 8 = 48
- Like the first step this doesn't free any addressing space in the TMSI. But some NRI values are now available in case it is wanted to share them with other nodes outside the '3 pool area'.
- In the example the NRI values 0..23 are shared and so are the TMSI ranges x000000xx .. x010111x



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		‘VLR-restart’						used NRI range																							

Figure 6: NRI-length can be reduced by 1 bit; VLR-restart field can increase to 4 bit.

‘3 pool configuration’ – full sharing of NRIs between the pools:

- The last variant of these configurations is a full sharing is all NRI values between all neighbouring pools. In this case no detection of pool area changes is possible. Consequently no distribution of load can be achieved. This results necessarily in the need to have a ‘forced redistribution’ mechanism to resolve heavy unbalance of load.
- The NRI and TMSI ranges will then be the same as in the ‘single pool’ example in the beginning.

Result:

The examples above show that it is basically not possible to configure the example configuration (32M non-purged subscribers; 1M per MSC) with a VLR-restart field as put in the assumptions, except that the full range of NRI is shared between the pools.
Taking it literally it could be possible with 3 pools when sharing the remaining quarter of the NRI (the part that would be unused otherwise), but latest if 4 pool-areas with this capacity have to be supported this reaches the limit.

An alternative to overcome this could be to apply the TMSI’s on a per LA basis as it is already foreseen on the A/Iu interface specifications.

TMSI per LA:

Taking the example configuration mentioned above but changing the TMSI allocation per LA would result in an increase of the addressing space. Then the same TMSI value can be used multiple times in the same VLR. A specific subscriber data record can then only be addressed by LA&TMSI.

For the 32 MSCs this means that that each of them supports an equal share of TMSI of a LA. So each MSC handles 2M/32 = 32k TMSI of a specific LA.

The required TMSI addressing space id thereby reduced to 15 bit per MSC.

If, like before, 96 NRI values are needed to address all nodes in the 3 pools then 7 bit are needed for this. This leaves 5 bit for the VLR-restart counters (plus 3 unused bits).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/ PS		‘VLR-restart’						used NRI range																							

Figure 7: TMSI example for TMSI allocation per VLR; 32M TMSI/pool;

Without sharing NRI values the pool size can even be increased (Factor 8 – since 3 bit spare).

A number of aspects however remain to be looked at with this TMSI per LA approach:

- It requires an equal distribution of UE’s of a certain LA over all nodes in the pool. This contradicts the wish for a flexible routing where e.g. a new attach should be routed to the closest node in order to save transmission resources.
- Attach requests in a LA may be rejected by one node because this node has already a fully booked TMSI table for this LA. At the same time the node may have in total still capacity left to serve subscribers…..
- The total load of TMSI re-allocations may increase since every change of LA must result in a TMSI reallocation.
- MAP on VLR-VLR I/F must be updated, otherwise subscriber confidentially decreases because for every change to other MSCs the IMSI has to be fetched via the air I/F. (At the same time node changes should only occur when changing the pool-area – so maybe never?)
- Can it happen that if NRI are shared there are several subscribers with the same TMSI in a certain LA? FFS
  If yes then a paging-request there will trigger several page-response messages per LA….

Annex D (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
					Version 0.0.0 Initial Proposal		
2001-04-20	Iu-flex drafting				Updates after drafting meeting		
2001-05-17	SA2#18				Adding S2-011369r1 chapter 5.3.1; alternative B chosen, A moved to annex and affected paragraphs updated accordingly; example network configurations added in annex C; some minor editorial corrections	0.1.0	0.2.0
2001-06-17	SA#12				Raised to version 1.0.0 (same technical content as v.0.2.0)	0.2.0	1.0.0