TSG-RAN meeting #3

Yokohama, Japan , 21-23, April,1999 *TSGR#3 (99)182*

Agenda Item: 4

Source: **TSG SA WG2**

Title: **Liaison statement on requirements on GSM/GPRS evolution for UMTS**

Document for: **Information**

TSG-SA Working Group 2 (Architecture) #03 *TSGS2#3 S2-990146*

Nynashamn, 15 - 19 March 1999

Title: **Liaison statement on requirements on GSM/GPRS evolution for UMTS**

Date: 19th March 1999

To: SMG10 WpC/ 3GPP TSG SA Wg3 (Security)

Cc: 3GPP TSG RAN, 3GPP TSG RAN Wg 3 (UTRAN Arch), 3GPP TSG Wg2 (CN),

Source: 3GPP TSG SA2

The 3GPP project and SMG has been developing the network and system aspects for UMTS based upon GSM evolution. Based upon this guiding principle, it is essential that the evolutionary developments and revisions to the current GSM/GPRS Phase 2+ standards to satisfy the UMTS requirements (including those for UMTS security) are identified.

TSG SA WG2 is developing the overall system aspects for UMTS and is keen to ensure that the developments needed to support the identified security features for UMTS are included within these system aspects.

TSG SA WG2 requests information from SMG10 WpC/ 3GPP TSG SA Wg3 (Security) regarding:
1. Additional requirements from UMTS security aspects compared to those of contemporary GSM/GPRS.
2. Evolution requirements to the GSM/GPRS Phase 2+ Core Network system, in particular highlighting any changes in security functionality location (within the architecture) compared to GSM/GPRS Phase2+.
3. Functional requirements to the UTRAN.
4. Impacts of the current working assumptions within 'The Evolution of the GSM platform towards UMTS' [See section 7 of 23.20 V1.5.0 attached].
5. Any approved or ongoing documentation regarding the security aspects of UMTS (in particular those related to security architecture).

In addition to this TSG SA Wg2 are interested in any implications and impacts of the current assumptions made regarding the support of the UMTS within an evolved GSM/GPRS network.

23.20 'The Evolution of the GSM platform towards UMTS' [V1.5.0] attached for information <u>(ELECTRONIC COPY ONLY FOR TSG-RAN)</u>.

Source:	**SMG 12**
Title:	**UMTS 23.20 version 1.5.0**
Purpose:	**Information**

DTR/SMG-032320U V.1.5.0 (1999-00)

Evolution of the GSM platform towards UMTS
UMTS 23.20 version 1.5.0

European Telecommunications Standards Institute

ETSI Secretariat

Copyright Notification

(

Contents

(

1. Intellectual Property Rights

2. Foreword

3. Introduction

4. Scope

This document is examining issues related to the evolution of the GSM platform towards UMTS with the overall goal of fulfilling the UMTS service requirements, the support of the UMTS role model, support of roaming and support of new functionality, signalling systems and interfaces.

5. References

This ETS incorporates, by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

1.   ETSI TC-SMG UMTS 22-01: "Services Principles"

2.   ETSI TC-SMG GSM 03.02

3.   ETSI TC-SMG GSM 03.60

4.   ETSI TC-SMG GSM 11.14

5.   ETSI TC-SMG GSM 30.01

6.   ETSI TC-SMG GSM 23.01.

7.   TG.3x6.

8.   UMTSYY.01, UE-UTRAN Radio Interface Protocol Architecture – Stage 2

9.   UMTSYY.03, Description of UE states and Procedures in Connected Mode

6 Definitions and abbreviations

6.1. Definitions

The following definitions have been introduced within this document.

Editors note : Reference to Definition document required.

6.2. Abbreviations

For the purposes of this ETS the following abbreviations apply.

7 Working assumptions

Section 7 is considered as relatively stable within SMG12, therefore interested groups are encouraged to use section 7 as an agreed SMG12 input to their work.~~Note: Section 8 gives agreed output from the key issues section and can therefore be seen as relatively stable with respect to release 99~~

7.1 General

The phase 1 UMTS/Release '99 GSM standards should provide the capability to support:

- a core network based on an evolved 2G MSC and an evolved SGSN

- an optionally evolved Gs interface

- class A GSM' mobiles.

- Transcoder location shall be according to 23.30

- UMTS/IMT2000 Phase1 (Release 99) network architecture and standards shall allow the operator to choose between Integrated and Separated core networks for transmission (including L2)

- The UMTS standard shall allow for both separated and combined MSC/VLR and SGSN configurations.

- The UE shall be able to handle separated or combined MSCs and SGSNs.

- There can be several user planes to these CN nodes.

The following general concepts should be followed :

- Separate the layer 3 control signalling from the layer 2 transport discussion (do not optimise layer 3 for one layer 2 technology).
- MSC-MSC layer 3 call control is out of scope of standardization in SMG.

7.2 Iu Interface

- Transport protocol across the Iu interface for UTRAN shall be according to 23.30

- The UTRAN shall support two logically separate signalling flows via Iu to combined or separate network nodes of different types (MSC and SGSN).

7.3 UMTS Mobility Management (UMM)

- From a logical point of view, the CN encompasses two domains, a PSTN/ISDN domain and an IP domain. It shall be possible to connect the UTRAN either to both these CN domains or to one of the CN domains.

- A single RRC connection (between UTRAN and UE) shall carry all user plane and signaling flows to/from a UE. This is regardless of where in the CN they originate/terminate.

- UMTS shall support compatibility with GSM network from the point of view of roaming and handover. For the LM/MM functionality point of view this implies among other things the following:

    a) IMSI shall be used as the common user identity in the two CN domains.

a) Common MAP signalling will be applied to both GSM and UMTS.The GSM MAP mobile service operations shall be evolved and re-used as far as possible (including extensions if required). This should not stop new MAP signalling operations being developed and applied to both GSM and UMTS.

b) Radio network parameters and radio resource management should be isolated in the UTRAN.

- The LM/MM techniques used in UMTS should minimise radio resource usage of the UTRA

7.3.1   Location Management and Mobility Management concept overview

From a logical point of view, the Core Network (CN) consists of two service domains, a CS service domain (earlier named PSTN/ISDN domain) and a PS service domain (earlier named IP domain) or one of these domains.

Each service domain has its own service state machine. An UE, that is supporting both CS services and PS services, has a CS service state machine and a PS service state machine. The two peers of the service state machine are working independently to each other, although associated to the same UE. The UE-CN signalling aims to keep the peer entities synchronized.

As an introduction, Figure 1 and Figure 2 below give an overview of the UE registration and connection principles within the UMTS when the CN consists of two separate PS and CS service nodes or one combined CS and PS service node.
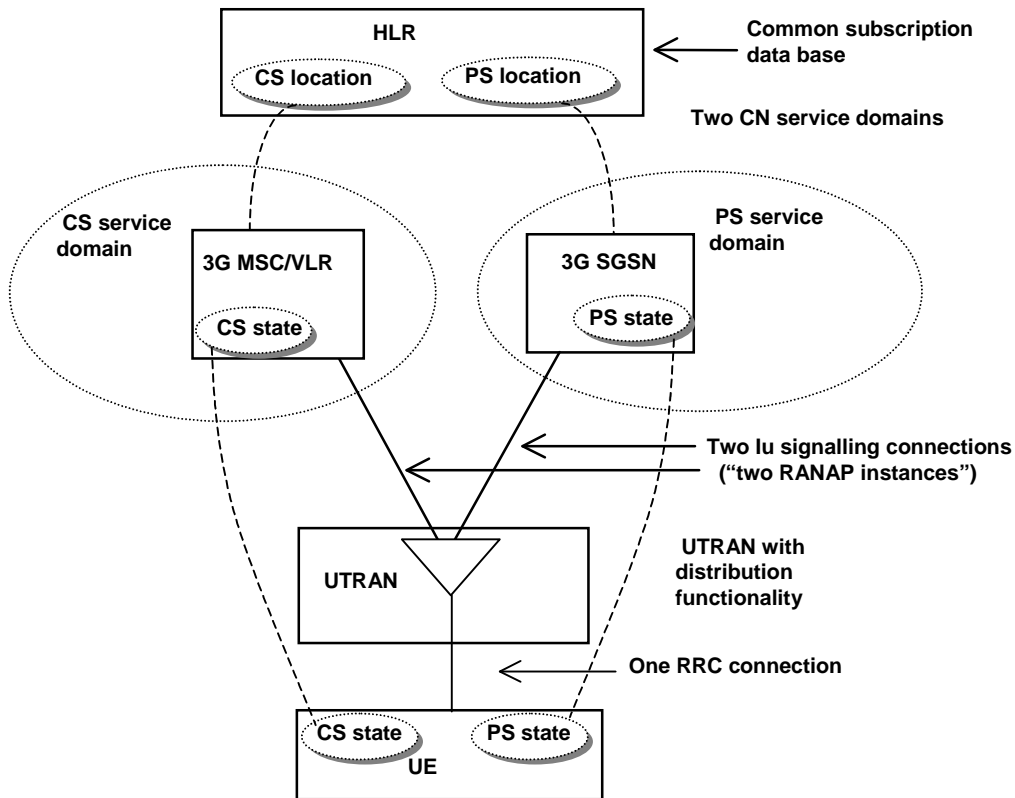
Figure 1: Overview of the UE registration and connection principles within UMTS for the separate CN architecture case when the CN consists of both a CS service domain with evolved MSC/VLR, 3G_MSC/VLR, as the main serving node and an PS service domain with evolved SGSN/GGSN, 3G_SGSN and 3G GGSN, as the main serving nodes,

(
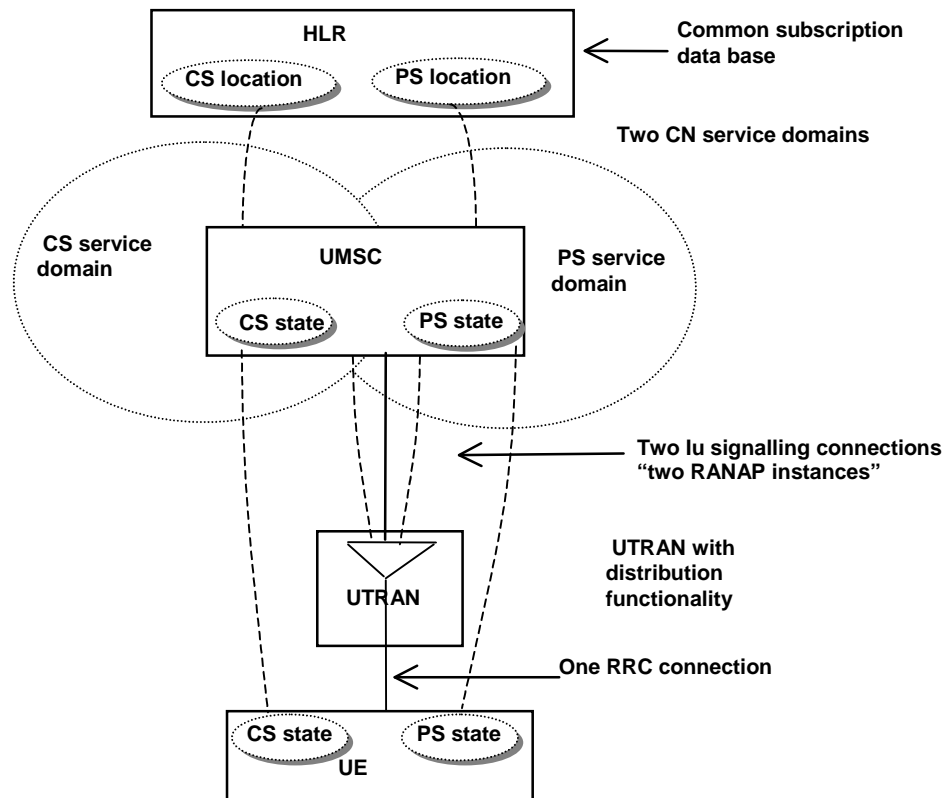
Figure 2: Overview of the UE registration and connection principles within UMTS for the integrated CN architecture case when the CN consists of both a CS service domain and an PS service domain with an UMSC as the main serving node.

The main PS service states are PS-DETACHED, PS-IDLE and PS-CONNECTED. The main CS service states are CS-DETACHED, CS-IDLE and CS-CONNECTED. For the respective service domain there are specific related MM system information controlling the Mobility Management functionality of the UE

The aim of UTRAN is to offer one unified set of radio bearers which may be used for bursty packet traffic and for traditional telephony traffic. This leads to the conclusion that only one logical control channel structure will be used for all kind of traffic. The radio resource handling is UTRAN internal functionality and the CN does not define the type of radio resource allocated.

The Radio Resource Control (RRC) has two modes, RRC Connected mode and RRC Idle mode. The RRC mode describes which identity is used to identify the UE. In RRC Idle mode the UE is identified by a CN associated identity. In RRC Connected mode the UE is assigned a Radio Network Temporary Identity to be used as UE identity on common transport channels. When the UE is allocated dedicated transport channels, it uses the inherent addressing provided by these transport channels.

In PS-CONNECTED state the UE is in RRC Connected mode. In CS-CONNECTED state the UE is in RRC Connected mode.

For the mobility functionality, four different area concepts are used. Location Areas and Routing Areas are used in the Core Network. UTRAN Registration Areas and Cell Areas are used in UTRAN. Location Areas are related to CS services. Routing Areas are related to PS services.

One Location Area is handled by one CN node. For an UE that is registered in a Location Area, this implies that the UE is registered in the specific CN node handling this specific Location Area. One Routing Area is handled by one CN node. For an UE that is registered in a Routing Area, this implies that the UE is registered in the specific CN node handling this specific Routing Area. Location Area is used by the 3G_MSC/VLR for paging the UE. Routing Area is used by the 3G_SGSN for paging the UE. UTRAN Registration Areas and Cell Areas are only visible in UTRAN and used in RRC-Connected mode.

For the relations between Location Area (LA) and Routing Area (RA) it shall be possible for the operator to have a LA and a RA equal (i.e. same cells), a RA as a part of a LA, a LA as a part of RA, and LA and RA independent. In case of a LA and RA consisting of both UMTS cells and GSM cells the GSM defined relations will apply.

In RRC Idle mode it is the broadcasted MM system information (e.g. information about the present Location Area and present Routing Area) that determinates when the UE initiates a location registration procedure towards the CN. An UE in state CS-IDLE will in RRC Idle mode, initiate Location Area update towards the CN when crossing LA border. An UE in state PS-IDLE will in RRC Idle mode initiate Routing Area update towards the CN when crossing RA border.

In RRC Connected mode, the UE receives the MM system information on the established RRC connection. (I.e. the broadcasted MM system information is not used by the UE in the RRC connected mode.) An UE in state CS-IDLE will, in RRC Connected mode, initiate Location Area update towards the CN when receiving information indicating a new Location Area. An UE in state PS-IDLE will, in RRC Connected mode, initiate Routing Area update towards the CN when receiving information indicating a new Routing Area. An UE in state CS-CONNECTED will, in RRC Connected mode, not initiate Location Area update towards the CN. An UE in state PS- CONNECTED will, in RRC Connected mode, not initiate Routing Area update towards the CN.

In CS-DETACHED mode the UE will not initiate any Location Area update and this independent of the RRC mode. In PS-DETACHED mode the UE will not initiate any Routing Area update and this independent of the RRC mode.

In additional to normal location registration when changing registration area, the UE may (network options) perform CS periodic registration when in CS-IDLE state and PS periodic registration when in PS-IDLE state. The respective periodic registration may be on/off on Location Area respective Routing Area level.

On the Mobility Management level, IMSI and CS related TMSI are used as UE identities in the CS service domain, and IMSI and PS related TMSI are used as UE identities in the PS service domain. The IMSI is the common UE identity for the two CN service domains.

A signalling connection between the UE and the CN refers to a logical connection consisting of an RRC connection between UE and UTRAN and an Iu signalling connection ("one RANAP instance") between the UTRAN and the CN node. The CS service domain related signalling and PS service domain related signalling uses one common RRC connection and two Iu signalling connections ("two RANAP instances"), i.e one Iu signalling connection for the CS service domain and one Iu signalling connection for the PS service domain.

7.3.1.1   Use of combined procedures for UMTS

The use of separated PS and CS mobility mechanisms within the UE and within the CN may lead to non-optimal usage of the radio resource (for example a UE in PS idle and CS idle state would perform both location updates (for the CS mechanism) and Routing area updates (for PS mechanisms)).

UMTS should optimise the use of radio resources., The use of combined updates (similar to the current GSM/GPRS Gs combined update mechanism) may enable this. To offer flexibility in the provision of mobility management for UMTS, it should be possible to use combined mechanisms for location management purposes as well as for attach/detach status purposes.

From the UE perspective it should be possible for the UE to perform combined update mechanisms (operator option). UMTS Phase 1 R99 terminals should support the use of both combined and separate mechanisms. The support of this feature by all UMTS mobiles will also ease evolution of UMTS MM in the future.

In the UMTS specifications the RAN will not coordinate mobility management procedures that are logically between the core network and the MS. This includes: location management, authentication, temporary identity management and equipment identity check.

The issues of security, temporary identifiers, CS and PS periodic registrations and PS DETACHED/CS DETACHED need to be studied.

7.3.2 Description of the Location Management and Mobility Management Concept

7.3.2.1   Area concepts

For the mobility functionality four different area concepts are used. Location Area and Routing Area in the CN as well as UTRAN Registration Area and Cell areas in the UTRAN.

7.3.2.1.1   Location areas

For CS services, the CN uses Location Areas (LA). Location Area is used e.g. at CN initiated paging related to CS services. A CS service related temporary identity, CS –TMSI, may be allocated to the UE. This temporary identity is then unique within a LA.

7.3.2.1.2   Routing areas

For PS services, the CN uses Routing Areas (RA). Routing Area is used e.g. at CN initiated paging related to PS services. A PS service related temporary identity, PS-TMSI, may be allocated to the UE. This temporary identity is then unique within a RA.

Note that the routing area concept here differs from the routing area in GSM, which in a sense corresponds to URA (see below) in UMTS.

7.3.2.1.3   UTRAN internal areas

UTRAN internal areas are used when the terminal is in RRC-Connected mode (see chapter 3.3). The areas are used at e.g. UTRAN initiated paging. UTRAN internal area updating is a radio network procedure and the UTRAN internal area structure should not be visible outside UTRAN. In RRC connected mode, the UE position is known on cell level or on UTRAN Registration Area (URA) level. RNTI is used as a temporary UE identifier used within UTRAN and allocated at RRC connection establishment. Note that the URA thus corresponds, in a sense, to the routing area in GSM.

7.3.2.1.4   Relationship between the different areas

The following area relations exist:

1) One URA consists of a number of cells. The cells normally belong to the same RNC, but this assumption may not be a requirement (ffs).

2) One RA consists of a number of URA:s belonging to RNC:s that are connected to the same CN node.

3) One LA consists of a number of URA:s belonging to RNC:s that are connected to the same CN node.

4) One RA is handled by only one CN serving node, i.e. one UMSC or one 3G_SGSN.

5) One LA is handled by only one CN serving node, i.e. one UMSC or one 3G_MSC/VLR.

6) There may not be any relation between LA and RA, i.e. the following relations between LA and RA are possible:
   - RA and LA is equal
   - one RA is a subset of one, and only one, LA, meaning that a RA do not span more than one LA
   - one LA is a subset of one, and only one, RA, meaning that a LA do not span more than one RA
   - independent LA and RA structure

In case of a LA and a RA consisting of both UMTS cells and GSM cells, then the GSM defined relations will apply.

Area Concepts
(Cells are not shown)
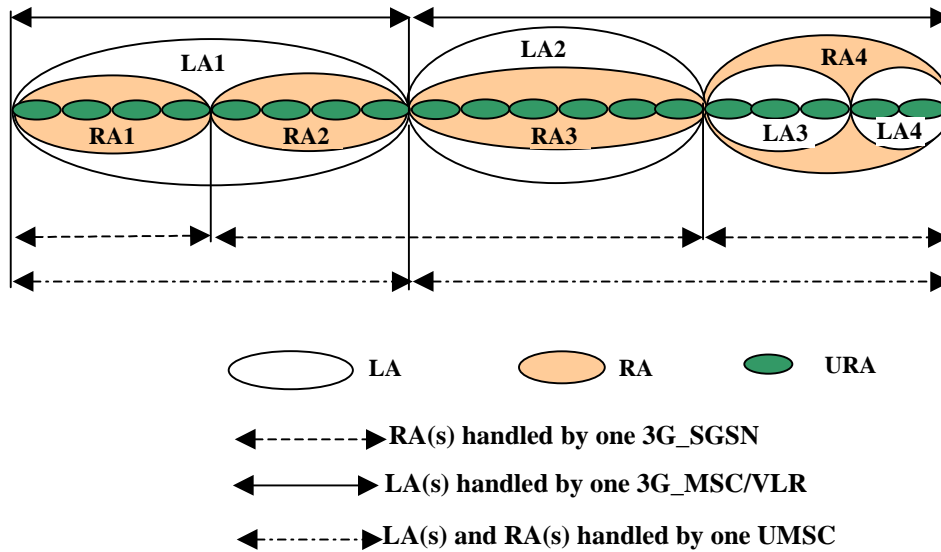
Figure 3: Relationship between different areas. The totally independent LA and RA structure is not described in this figure.

7.3.3 MM functionality in different UE service states

Below are the main UE service states and related MM functionality described. For the determination on when LA or RA is changed, see chapter on "Handling of MM system information".

CS service states and related MM functionality:

1) 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.

2) CS-IDLE: The UE is reachable by paging for CS services. The UE initiates LA updates at LA changes. The UE may initiate periodic CS service updates and this depending on the CS periodic update state of the present LA.

3) 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) and no periodic CS service updates.

PS service states and related MM functionality:

1) PS-DETACHED: 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.

2) PS-IDLE: The UE is reachable by paging for PS services. The UE initiates RA updates at RA changes. The UE may initiate periodic PS service updates and this depending on the PS periodic update state of the present RA.

3) PS-CONNECTED: The UE has a signalling connection for PS services established between the UE and the CN. The UE does not initiate RA update (even not when the present RA changes) at RA changes and no periodic PS service updates.

There may also be a NULL state. In the UE, this state corresponds to power off or maybe a "no SIM" condition. In the CN, the NULL state correspond to CS-DETACHED and PS-DETACHED

For each state transition there can be several events that triggers the transition. Some of them are described below. Note that some of these may coincide, e.g. moving from CS-IDLE to CS-DETACHED and moving from PS-IDLE to PS-DETACHED.

Moving from CS-IDLE to CS-CONNECTED:

The state transition from CS-IDLE to CS-CONNECTED is performed when a signalling connection is established between UE and CN for CS services. In GSM this state transition is triggered by the message CM_SERVICE_REQUEST or PAGE_RESPONSE.

Moving from CS-CONNECTED to CS-IDLE:

The state transition from CS-CONNECTED to CS-IDLE is performed when the signalling connection for CS services is released, e.g. at call release and no other CS service is ongoing. A radio link failure may also trigger this state transition.

Moving from CS-IDLE to CS-DETACHED:

The transition from CS-IDLE to CS-DETACHED may be triggered by some action from the user of the UE but an expiring timer in the network could also trigger it. The UE is marked as CS_DETACHED in the CN and then as a consequence no CS service establishment is possible.

Moving from PS-IDLE to PS-CONNECTED:

The state transition from PS-IDLE to PS-CONNECTED is performed when a signalling connection is established between UE and CN for PS services.

Moving from PS-CONNECTED to PS-IDLE:

The state transition from PS-CONNECTED to PS-IDLE is performed when the signalling connection for PS services is released, e.g. at release of a PS service and no other PS service is ongoing. A radio link failure may also trigger this state transition.

Moving from PS-IDLE to PS-DETACHED:

The transition from PS-IDLE to PS-DETACHED may be triggered by some action from the user of the UE but an expiring timer in the network could also trigger it. The UE is marked as PS_DETACHED in the CN and then as a consequence no PS service establishment is possible.

7.3.4   The RRC state machine

The RRC state machine is a description model of how the UE and the UTRAN co-operate regarding RRC functionality. The RRC state describes the state of the UE in the UTRAN. Here follows a brief description of the RRC state machine, for more information see [UMTS YY.01] and [UMTS YY.03].

Note: RRC idle mode and RRC connected mode refer to the UE idle mode and UE connected mode respectively in [UMTS YY.01] and [UMTS YY.03].

The RRC state machine exists as peer entities, one in the UE and one in UTRAN. Apart from transient situations and error cases they are synchronized. The figure below illustrates the main modes/states of the RRC state machine.
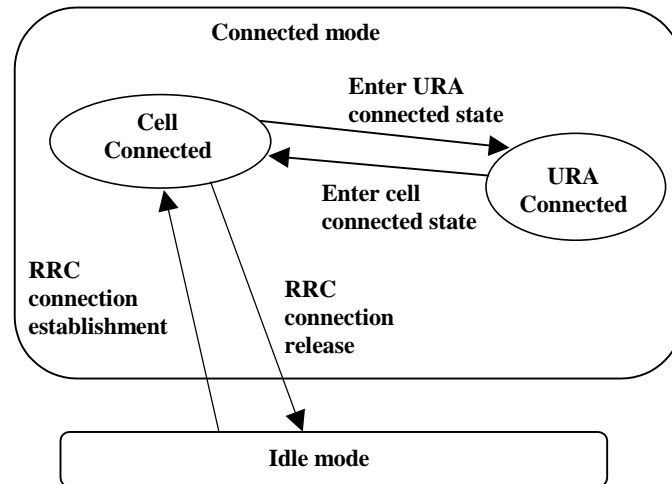
Figure 4: RRC modes, main RRC states and main mode/state transisions

RRC-Idle_mode
In the Idle mode there is no connection established between UE and UTRAN. There is no signalling between UTRAN and the UE except for system information that is sent from UTRAN down link on a Broadcast channel to the UE. The UE can also receive paging messages with a CN identity on the PCH. There is no information on the UE stored in UTRAN in this state.

RRC-Connected_mode
In the Connected mode the main states are Cell Connected state and URA connected state. In this mode there is one RNC that is acting as Serving RNC (SRNC), and an RRC connection is established between the UE and this SRNC.

- When the UE position is known on cell level, the UE is in the cell connected state. When in cell connected state, the RRC connection mobility is handled by handover procedures.

- When the UE position is known on URA level, the UE is in the URA connected state. The URA contains a set of cells. URA updating procedures provides the mobility functionality in this state. In URA connected state no dedicated radio resources are used.

7.3.5 Relationship between CS and PS service states and RRC state for an UE

During non-transient conditions the following relations are valid between service states and RRC modes for an UE:

RRC idle mode ⇔ CS-IDLE or CS-DETACHED

RRC idle mode ⇔ PS-IDLE or PS-DETACHED.

RRC connected mode ⇔ CS-CONNECTED

RRC connected mode ⇔ PS CONNECTED

Figure 5 and Figure 6 illustrate two examples on the relations between the RRC states and CS/PS service states. These figures illustrate the separated CN case.
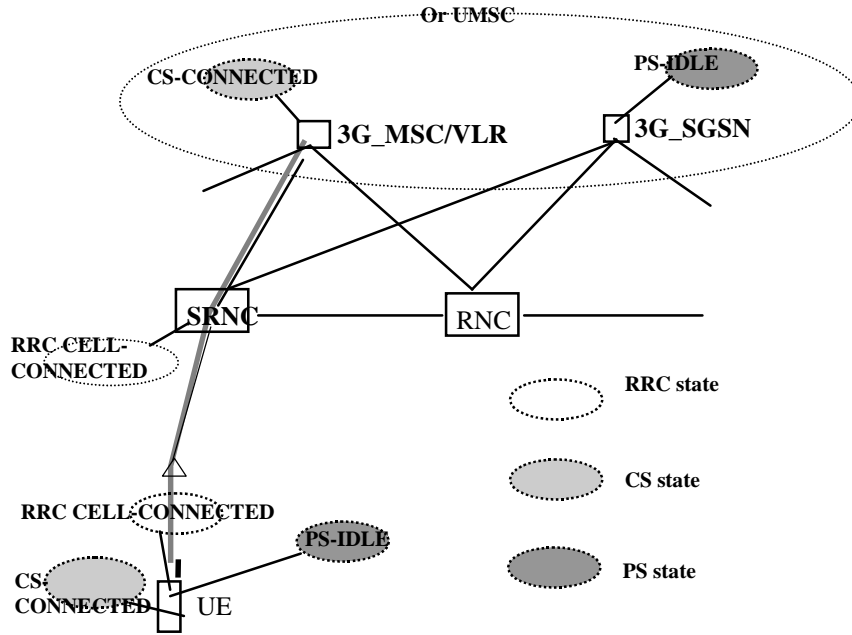
Figure 5: UE in CS-CONNECTED state and PS-IDLE state.
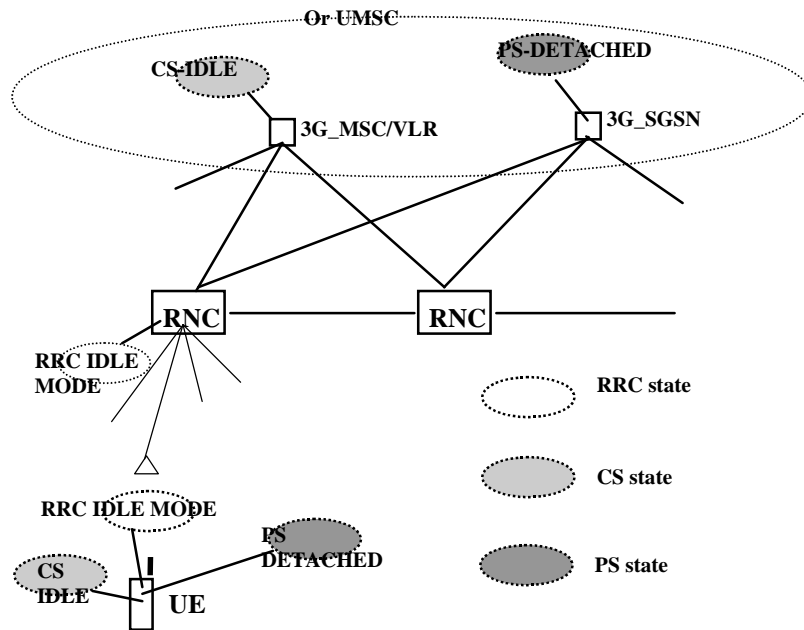
Figure 6

7.3.6 Service registration and location update

Service registration (attach) in the respective CN service domain is done initially (after UE being detached due to e.g. power off). When a registration area is changed a location update is performed. In addition, periodic registration can be performed. Here follows descriptions of when the respective CN registration area is changed. Note it is not here defined which different registration procedures that are needed.

7.3.6.1 Location area update

Location area update is initiated by the UE to inform the CS service domain of the core network that the UE has entered a new location area. In case the new location area is in an area served by another CN node, the location area update also triggers the registration of the subscriber in the new CN node and a location update for CS services towards the HLR.

Location area update is only initiated by the UE when the UE is in state CS-IDLE, and this independently of the PS state. If the UE is CS-IDLE but RRC connected, which means that the UE is in PS-CONNECTED state, location area update is initiated by the UE when it enters a new location area (see also the chapter "Handling of MM system information").

7.3.6.2 Routing area update

Routing area update is initiated by the UE to inform the PS service domain of the core network that the UE has entered a new routing area. In case the new routing area is in an area served by another CN node, the routing area update also triggers the registration of the subscriber in the new CN node and a location update for PS services towards the HLR.

Routing area update is only initiated by the UE when the UE is in state PS-IDLE, and this independently of the CS state. If the UE is PS-IDLE but RRC connected, which means that the UE is in CS-CONNECTED state, routing area update is initiated by the UE when it enters a new routing area (see also the chapter "Handling of MM system information").

7.3.6.3 Combined updates

The GSM radio interface combined procedures and their support via the Gs interface is the starting point for the support of combined updates..

7.3.7 Paging initiated by CN

Here follows a possible solution with a page co-ordination within the UTRAN. Other alternatives are possible.

* A CN node requests paging only for UE in CS-IDLE state or PS IDLE state. In the separate CN architecture, paging from a CN node is done independent of the service state of the UE in the other CN service domain.

* In this alternative with page co-ordination in UTRAN, the UE does not need to listen to the PCH (Page Channel) in RRC connected mode. (At least not when UE is allocated a dedicated channel.)

* At each page request received from a CN node, the RNC controls whether the UE has an established RRC connection or not. For this, the context that is build up in the SRNC for UE in RRC connected mode must contain the IMSI, i.e. the UE identity common for the two CN domains.

* If no context is found for the UE, "normal PCH paging" is performed. This implies transfer on the Paging channel of a page message indicating the UE paging identity received from the CN and a CN service domain type indication.

* If a context is found, a "CN paging message" is transferred using the existing RRC connection. This message indicates then the UE paging identity received from the CN and a CN service domain type indication.

* In case of a single CN element, paging may be (but not mandatory) co-ordinated at the CN.

Note: The RNC might use another identity e.g. TMSI, P-TMSI, or other radio related identity, to page the mobile.

7.3.8 Signalling connection establishment

A signalling connection between the UE and a CN node refers here to a logical connection consisting of an RRC connection between UE and UTRAN and an Iu signalling connection between UTRAN and the CN node. The signalling connection is used for transfer of higher layer (MM, CM) information between the UE and the CN node.

At a CM service request to one of the CN service domains, UE will only request establishment of a new signalling connection when no such connection exists towards the applicable CN service domain.

If no RRC connection exists, this is established in conjugation with (before) the transfer of the signalling establishment request. At the RRC connection establishment, an UE context is built up in the SRNC.

If an RRC connection is already established, the UE will send the signalling establishment request using that RRC connection.

At reception of the signalling establishment request, the SRNC will establish an Iu connection towards the CN node indicated by the CN service domain type received from UE.

7.3.9   Relations between SRNS relocation and Location registration

This chapter is included in order to clarify the need for separate handling of MM registration area (LA and RA) information in RRC idle mode respective in RRC connected mode. The following example illustrates relations between SRNC relocation, registration area (LA/RA) change and location/routing area updates. As shown in the example, this is equally applicable for a UMSC as well as the 3G-MSC/VLR and 3G-SGSN.

Note that the example is based on the assumptions that one RNC can set up Iu connections to only one 3G_MSC/VLR (or UMSC) and only one 3G_SGSN (or UMSC), and that the CN node is configured to only send page to the RNC(s) that is controlling cells within the relevant LA/RA

Preconditions:

- LA1 (Location Area 1) is handled by 3G_MSC/VLR1 (or UMSC1) and LA2 is handled by 3G_MSC/VLR2 (or UMSC2)

- RA1 (Routing Area 1) is handled by 3G_SGSN1 (or UMSC1) and RA2 is handled by 3G_SGSN2 (or UMSC2)

- UE is registered in LA1 in 3G_MSC/VLR1 and in RA1 in 3G_SGSN1

- The UE is in PS-CONNECTED state and a signalling connection exists between UE and 3G_SGSN1

- The UE is in CS-IDLE state and no signalling connection exists between UE and 3G_MSC/VLR1

- 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 UE can always (at least in normal working states) identify the present available registration area (LA respective RA) associated with the respective CN service domain. The determination of the present area differs depending on the state of the UE. For UE in RRC idle mode (UE with no ongoing communication with the network) it is the cell selection mechanism in the UE that is used. For UE in RRC connected mode it is the UTRAN that determines the area (although a change can implicit be initiated by the UE).

It is the network that supplies the MM system information to the UE. For UE in RRC idle mode the MM system information is provided by the system information broadcasting function. For UE in RRC connected mode, the MM system information is supplied by the SRNC to the UE at each change of this information. This leads to that in RRC connected mode, the MM registration area (e.g. LA and RA) information sent on broadcast channel is not used.
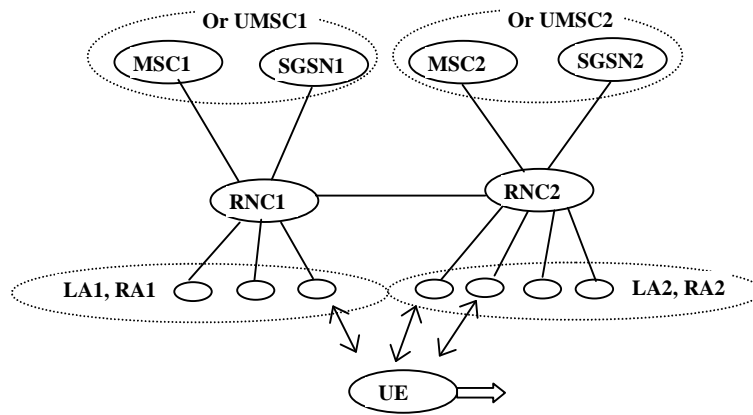
Figure 7: Illustration of the preconditions in the described example. In this figure MSC stands for 3G_MSC/VLR and SGSN for 3G_SGSN.

The UE moves now further towards right, leaving the coverage area of cells controlled by RNC1, and resulting in that the UE has dedicated channel(s) established to cell(s) within only RNC2. This may result in the following sequence of events:

- The SRNC (RNC1) may decide to perform an SRNC relocation resulting in that the RNC2 becomes SRNC. The change of SRNC will in this example also imply a change of SGSN (or UMSC) with an update of the UE location registration for the PS service domain.

- After this SRNC relocation or combined with this procedure, the MM registration area information sent to the UE is changed and indicates now LA2 and RA2. (Note that 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 changed MM registration area information will result in that the UE initiates a location update, which results in a registration change from LA1 in 3G_MSC/VLR1 to LA2 in 3G_MSC/VLR2.

The area information can not be changed to indicate LA2 unless SRNC relocation has been performed. This since the location update signalling will be sent from the UE, by using the established RRC connection to SRNC, and then to the 3G_MSC/VLR to which the SRNC belongs.

7.3.10 Requirements on Identifiers for UMTS and GSM

1a) The format of the UMTS Location Area Identifier and UMTS TMSI shall not prevent a dual mode GSM-UMTS mobile which was last location updated over the GSM radio interface (ie has a GSM LAI and GSM TMSI), from performing a location update (or other signalling) over the UMTS radio interface to a UMTS MSC.

1b) The format of the UMTS Location Area Identifier and UMTS TMSI shall not prevent a dual mode GSM-UMTS mobile which was last location updated over the UMTS radio interface (ie has a UMTS LAI and UMTS TMSI), from performing a location update (or other signalling) over the GSM radio interface to a GSM MSC.

1c) The format of the UMTS Routing Area Identifier and UMTS P-TMSI shall not prevent a dual mode GSM-UMTS mobile which was last routing area updated over the GSM radio interface (ie has a GSM RAI and GSM P-TMSI), from performing a routeing area update (or other signalling) over the UMTS radio interface to a UMTS SGSN.

1d) The format of the UMTS Routing Area Identifier and UMTS P-TMSI shall not prevent a dual mode GSM-UMTS mobile which was last routing area updated over the UMTS radio interface (ie has a UMTS RAI and UMTS P-TMSI), from performing a routeing area update (or other signalling) over the GSM radio interface to a GSM SGSN.

2) The standard shall support means by which an operator can configure GSM and UMTS cells to be members of the same registration area (ie the mobile can receive paging from whichever cell it is camped on and does not need to location update (or routing update) just because the mobile has changed from a UMTS to a GSM cell).

3a) The standard shall support means by which an operator can allocate GSM and UMTS LAIs which enable GSM MSCs to be able to contact UMTS MSCs and vice versa.

3b) The standard shall support means by which an operator can allocate GSM and UMTS RAIs which enable GSM SGSNs to be able to contact UMTS SGSNs and vice versa.

4) The standard shall support means by which an operator can ensure that the IMSI does not need to be sent over the radio interface when the mobile station moves from a GSM cell to a UMTS cell (and vice-versa).

5) The standard shall support means by which an operator can ensure that the IMSI does not need to be sent over the radio interface when a USIM is moved from a UMTS mobile station to a GSM mobile station (and vice-versa).

6) The standard need not support means by which an operator can ensure that the IMSI is not sent over the radio interface when a GSM SIM is moved from a GSM mobile station to a UMTS mobile station (and vice-versa).

7.3.11 Use of TMSI signature

The TMSI signature concept would mainly be used during the IMSI attach procedure and during the location update procedure. (The former may invokes the latter) However, it may also be used in almost all cases when authentication is performed e.g. call setup. Note that if the TMSIS is sent in the clear, then a new one should be issued.

As the use of a P-TMSI signature is already defined within GPRS, only the modifications necessary for CS service domain shall be shown below.

7.3.11.1 IMSI attach

Figure 1 shows the signalling procedure for *a first time (IMSI based) attach (i.e. when no TMSI is available in the UE).* The following list explains the relevant steps involved in the procedure.
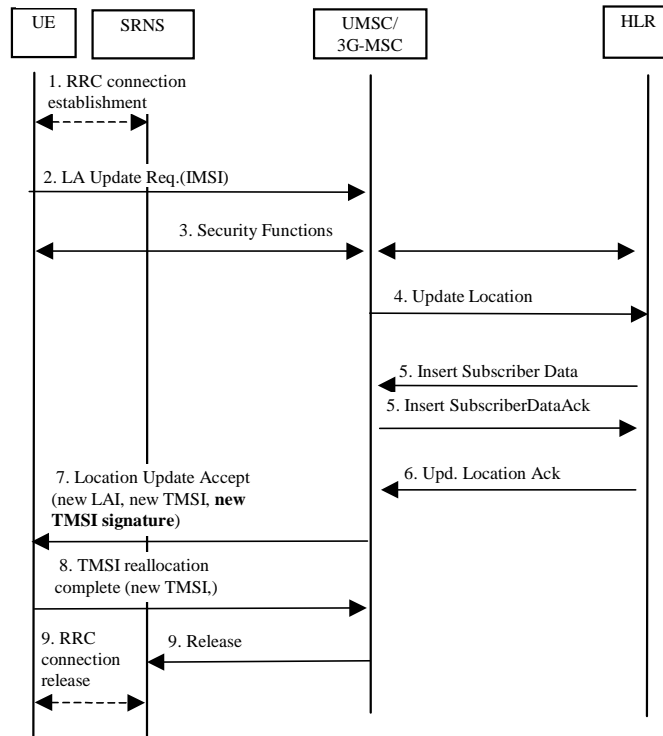
Figure 8: Attach Procedure using TMSI signature

1). An RRC connection is established.

2). Apon the very first attach towards the network, the MS shall send a Location Area Update Request message towards the MSC/UMSC, indicating an IMSI attach, and identifying itself with IMSI.

2 – 6) The LA updating procedure shall be carried out as per normal within the network.

7). The MSC/UMSC shall optionally generate and send a TMSI signature within the Location Area Update Accept message to the MS, which will be stored by the MS.

8) The MS acknowledges the new TMSI.

9). The RRC connection may be released.

7.3.11.2 Location Area update

Figure 2 shows the signalling for a location update procedure involving change of 3G-MSC / UMSC. Note that when the authentication procedure using TMSI signature is successful, security functions using Ki are no longer required. The following list explains the relevant steps involved in the procedure.
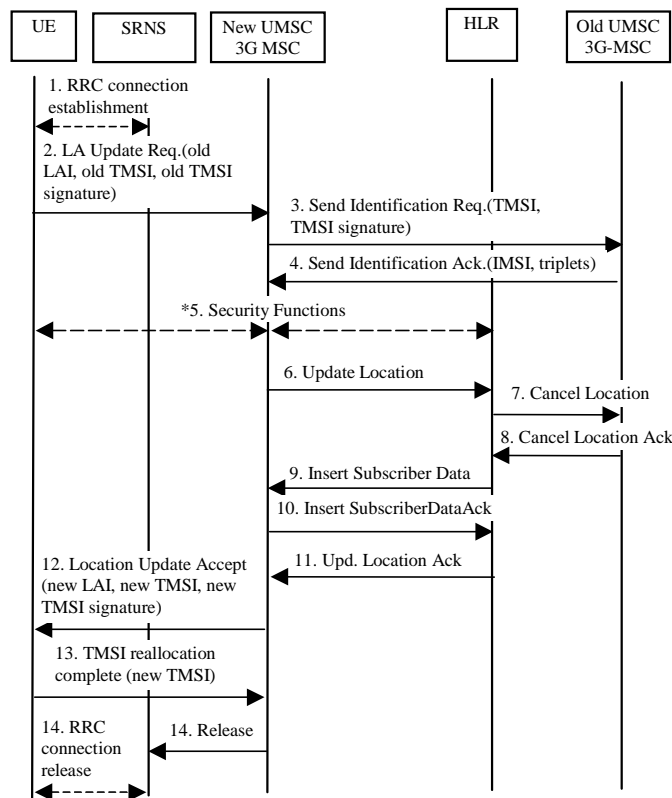
Figure 9: Location Update using TMSI signature

1) An RRC connection is established.

2) The UE shall send a Location Area Update Request (old LAI, old TMSI, old TMSI signature) towards the new UMSC/MSC.

3-5) The new UMSC/MSC shall send a Send Identification Request (TMSI, TMSI signature) to the old UMSC/MSC. The old UMSC validates the old TMSI signature and responds with an appropriate error cause if it does not match the value stored. This should initiate the security function in the new UMSC. Otherwise, the old UMSC responds with a Send Identification Acknowledge (IMSI, Authentication triplets).

6-11) The LA updating procedure shall be carried out as per normal within the network.

12) The new UMSC/MSC shall optionally generate and send a TMSI signature within the Location Area Update Accept message to the UE.

13) The UE acknowledges the new TMSI.

14) The RRC connection may be released.

7.3.11.3 MM System Information

The system information that is needed for the Mobility Management functionality contains parameters such as:

MCC, MNC, LAC, RAC, Periodic Location Area Update timer, and Periodic Routing Area Update timer.

In each UMTS cell (UTRAN cell) the network broadcasts MM system information on the broadcast channel. In RRC idle mode, when the UE camps on one cell, it receives all MM system information valid for this cell on the broadcast channel of the cell. The received MM system information is then the "current MM system information".

In RRC connected mode, it is the responsibility of the SRNS to control the current MM system information valid for the UE. At any changes, the established RRC connection is used for transferring the new MM system information to the UE. E.g. at SRNS relocation, the new SRNS shall have logic for sending applicable MM system information to the UE. This information is determined by e.g. the Location Areas and the Routing Areas handled by the respective CN node to which the SRNS can set up Iu signalling connections. At reception of new MM system information from the SRNC on the established RRC connection, the UE uses this new information as the "current MM system information". (Note that the MM system information need not necessarily be sent for every SRNSs relocation, nor does it prelude MM system information being sent on other occasions.)

At the RRC connection establishment, the UE uses the broadcasted MM system information of the cell where the establishment is made as the "current MM system information".

When the UE leaves the RRC connected mode and enters RRC idle mode, the UE uses the broadcasted MM system information of the chosen cell, which is determined by the UE idle mode cell selection/re-selection process that is then performed, as the "current MM system information".

The "current MM system information" is used by the MM functionality in the UE respecting the rules for the UE service state of the respective MM state machine, see ' 7.3.3 MM functionality in different UE service states ' and ' 7.3.6 Service registration and location update '.

7.3.11 Signalling procedures

7.3.11.1 Idle mode procedures

The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation. By default the combined procedures as defined in GSM 03.60 are also applicable when using Gs.

Furthermore the list of parameters may not be complete, but should only be seen as examples of possible information carried by the messages.

7.3.11.1.1 Location Area update

This example shows location registration when changing Location Area including change of 3G-MSC/VLR and when the UE is in MM idle state towards the 3G_MSC/VLR.

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.

For each indicated MM message sent in this case to/from UE, the CN discriminator indicates 3G_MSC/VLR.
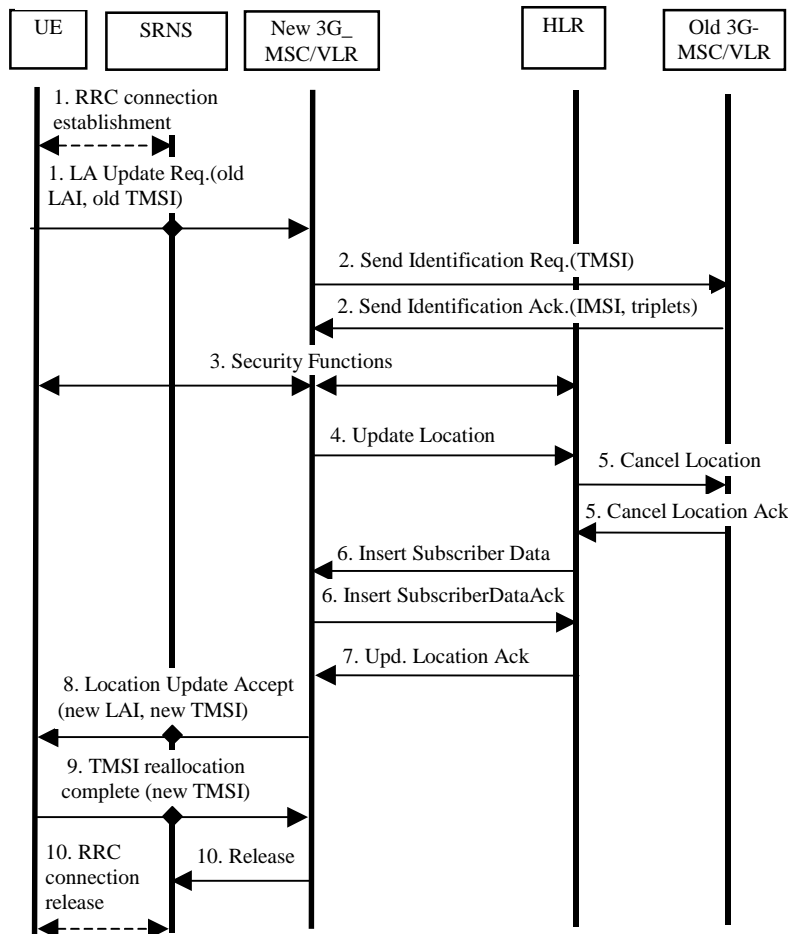
Figure 10: Interface information transfer for location update when changing VLR area

1)   The RRC connection is established, if not already done. The UE sends the initial message Location Area Update
        Request (old TMSI, old LAI, etc.) to the new 3G_MSC/VLR. The old TMSI and the old LAI are assigned data
        in UMTS. The SRNS transfers the message to the 3G_MSC/VLR. The sending of this message to
        3G_MSC/VLR will also imply establishment of a signalling connection between SRNS and 3G_MSC/VLR for
        the concerned UE. The 3G_MSC/VLR determinates the new Location Area for the UE. Whether the
        3G_MSC/VLR derives the new LAI from information supplied by the UE or by the SRNS is ffs.

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 LA. If due to regional, national or international
        restrictions the UE is not allowed to attach in the LA or subscription checking fails, then the new 3G_MSC/VLR

rejects the location area update with an appropriate cause. If all checks are successful, then the new 3G_MSC/VLR responds to the UE with Location Area Update Accept (new TMSI, new LAI).

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 may release the signalling connection towards the SRNS for the concerned UE. The SRNS will then release the RRC connection if there is no signalling connection between 3G_SGSN and SRNS for the UE.

7.3.11.1.2 Routing Area update

This example shows location registration when changing Routing Area including change of 3G_SGSN when the UE is in MM idle state towards the 3G_SGSN.

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_MSC/VLR or be established only for this location registration procedure towards the 3G_SGSN.

For each indicated MM message sent in this case to/from UE, the CN discriminator indicates 3G_SGSN.
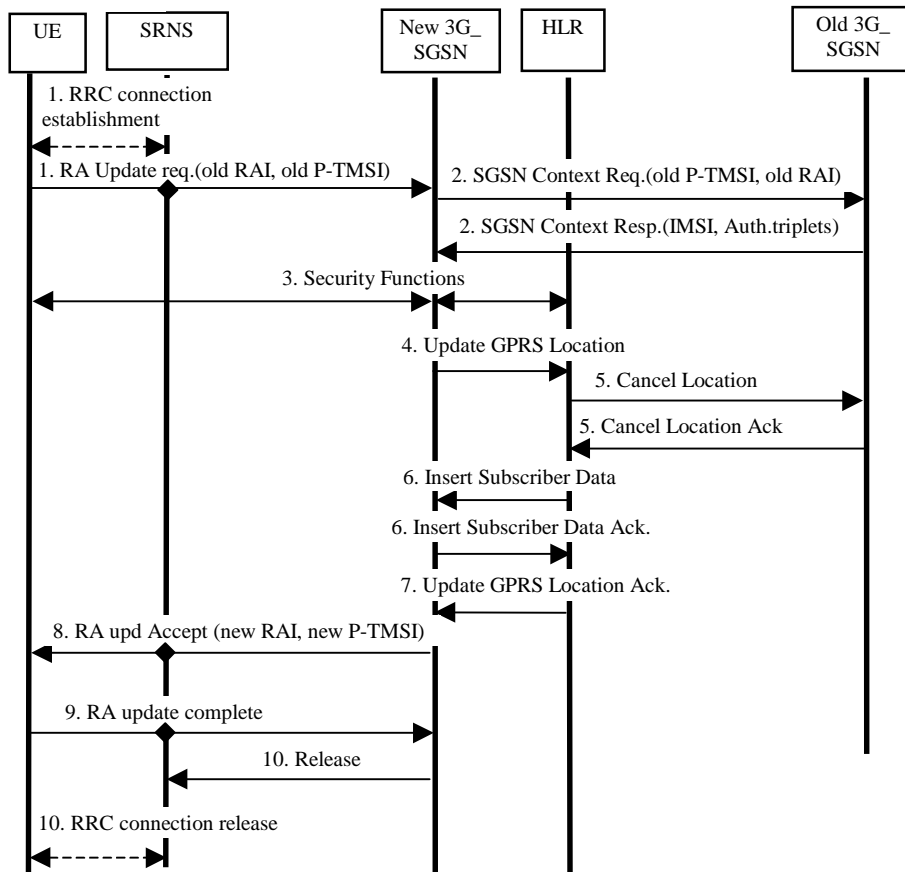
Figure 11 Interface information transfer for Routing Area update when changing SGSN area (successful case)

1)   The RRC connection is established, if not already done. The UE sends the initial message Routing Area Update Request (old P-TMSI, old RAI, etc.) to the new 3G_SGSN. The old P-TMSI and the old RAI are assigned data in UMTS. The SRNS transfers the message to the 3G_SGSN. The sending of this message to 3G_SGSN will also imply establishment of a signalling connection between SRNS and 3G_SGSN for the

concerned UE. The 3G_SGSN determinates the new Routing Area for the UE. Whether the 3G_SGSN derives the new RAI from information supplied by the UE or by the SRNS is ffs.

2) The new 3G_SGSN send an SGSN Context Request (old P-TMSI, old RAI) to the old 3G_SGSN to get the IMSI for the UE. (The old RAI received from UE is used to derive the old 3G_SGSN identity/address.) The old 3G_SGSN responds with SGSN Context Response (e.g. IMSI and Authentication triplets).

3) Security functions may be executed.

4) The new 3G_SGSN informs the HLR of the change of 3G_SGSN by sending Update GPRS Location (IMSI, SGSN number, SGSN address) to the HLR.

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

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

7) The HLR acknowledges the Update GPRS Location by sending Update GPRS Location Ack. to the new 3G_SGSN.

8) The new 3G_SGSN validate the UEs presence in the new RA. If due to regional, national or international restrictions the UE is not allowed to attach in the RA or subscription checking fails, then the new 3G_SGSN rejects the Routing Area Update Request with an appropriate cause. If all checks are successful, then the new 3G_SGSN responds to the UE with Routing Area Update Accept (new P-TMSI, new RAI, etc.).

9) The UE acknowledges the new P-TMSI with Routing Area Update Complete.

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

7.3.11.1.3 Periodic Registration towards both CN nodes without use of Gs

This example shows Periodic Registration to both the 3G_MSC/VLR and the 3G-SGSN (i.e. no change of registration areas) when the UE is in MM idle state and registered in both the 3G_SGSN and the 3G_MSC/VLR.

The illustrated transfer of MM signalling to/from the UE uses an established RRC connection. This RRC connection will be established, is in this case, only for the two registration procedures towards the 3G_SGSN and 3G_MSC/VLR.

For each indicated MM message sent to/from UE, the CN discriminator indicates either 3G_ SGSN or 3G_MSC/VLR.
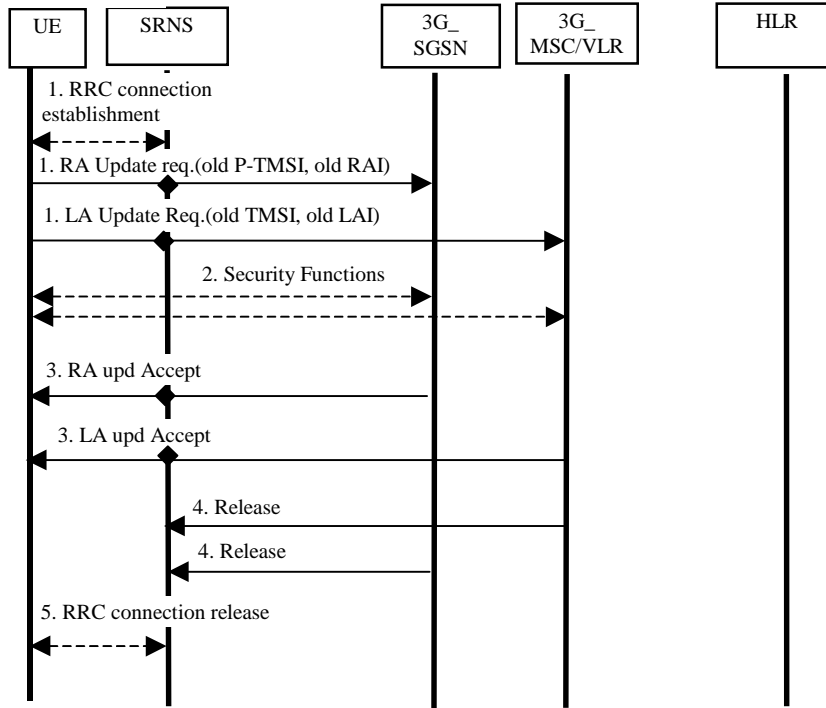
Figure 12 Interface information transfer for periodic registration to 3G_SGSN and 3G_MSC/VLR (successful case)

1) The RRC connection is established. The UE sends the initial messages Routing Area Update Request (old P-TMSI, old RAI, etc.) to the 3G_SGSN and Location Area Update Request (old TMSI, old LAI, etc) to the 3G_MSC/VLR. In both cases, the UE will indicate the cause periodic registration. The sending of the respective message to SGSN respective to MSC/VLR will also imply establishment of a signalling connection between SRNS and SGSN and a signalling connection between SRNS and MSC/VLR for the concerned UE.

2) Security functions may be executed.

3) The 3G_SGSN respective the 3G_MSC/VLR validates the UEs presence. If all checks are successful, then the 3G_SGSN responds to the UE with Routing Area Update Accept and 3G_MSC/VLR responds to the UE with Location Area Update Accept.

4) When the periodic registration procedure is finished, the 3G_SGSN respective the 3G_MSC/VLR may release the signalling connection towards the SRNS for the concerned UE. If both CN noded releases the signalling connection towards the SRNS for the concerned UE, then the SRNS will release the RRC connection towards the UE.

7.3.11.1.4 Periodic Registration with use of Gs/UMSC
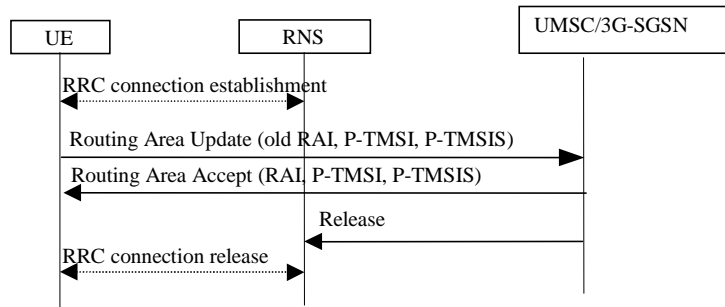
Figure 13: Periodic update procedure when the MS is attached for both CS and PS services

An RRC connection is established for the periodic registration. Note that this procedure is invoked only when the UE is in MM-idle state. The UE sends a Routing Area Update to the UMSC. The UMSC authenticates the P-TMSI signature. If the update is successful it sends a Routing Area Accept message. The RRC connection is then released.

7.3.11.1.5 UE initiated Combined Detach Procedure when using Gs/UMSC

The UE-Initiated Detach procedure when initiated by the UE is illustrated in Figure 30. Each step is explained in the following list.
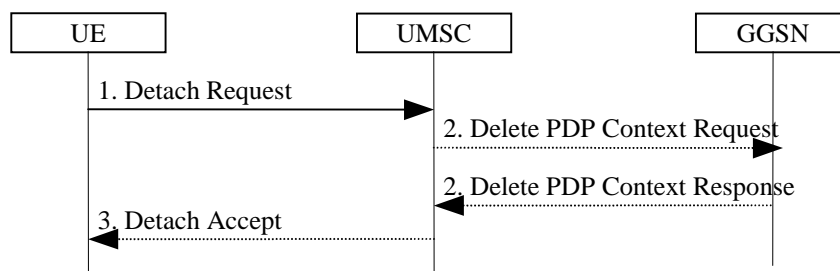
Figure 29: UE-Initiated Combined Detach Procedure (The procedure for combined detach when using Gs is as defined in GSM 03.60)

1) The UE detaches by sending Detach Request (Detach Type, Switch Off) to the UMSC. Detach Type indicates which type of detach that is to be performed, i.e., PS Detach only, CS Detach only or combined Detach. Switch Off indicates whether the detach is due to a switch off situation or not.

2) If PS detach, any active PDP contexts in the GGSNs regarding this particular UE may be deactivated. This is FFS

3) If Switch Off indicates that the detach is not due to a switch off situation, the UMSC sends a Detach Accept to the UE.

7.3.11.2 SRNS Relocation

The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation. In these examples MSC stands for 3G_MSC/VLR and SGSN stands for 3G_SGSN.

Furthermore the list of parameters may not be complete, but should only be seen as examples of possible information carried by the messages.

7.3.11.2.1 SRNS relocation (UE connected to a single CN node, 3G_MSC/VLR) followed by Location Registration in new Routing Area

This example shows SRNS relocation when source RNC and target RNC are connected to different 3G_MSC/VLR. This is then followed by a Routing Area update procedure towards a new SGSN. Figure 14 and Figure 15 illustrate the situation before respective after the SRNS relocation and location registration. Figure 16 illustrates the signalling sequence where each step is explained in the following list.

Figure 14 Before the SRNS relocation and location registration

Before the SRNS relocation and location registration the UE is registered in SGSN1 and in MSC1. The UE is in state MM idle towards the SGSN1 and in state MM connected towards the MSC1. The RNC1 is acting as SRNC and the RNC2 is acting as DRNC.

Figure 15 After the SRNS relocation and location registration

After the SRNS relocation and location registration the UE is still registered in MSC1 while the registration in the IP domain has changed from SGSN1 to SGSN2. The UE is in state MM idle towards the SGSN2 and in state MM connected towards the MSC1. The RNC2 is acting as SRNC.
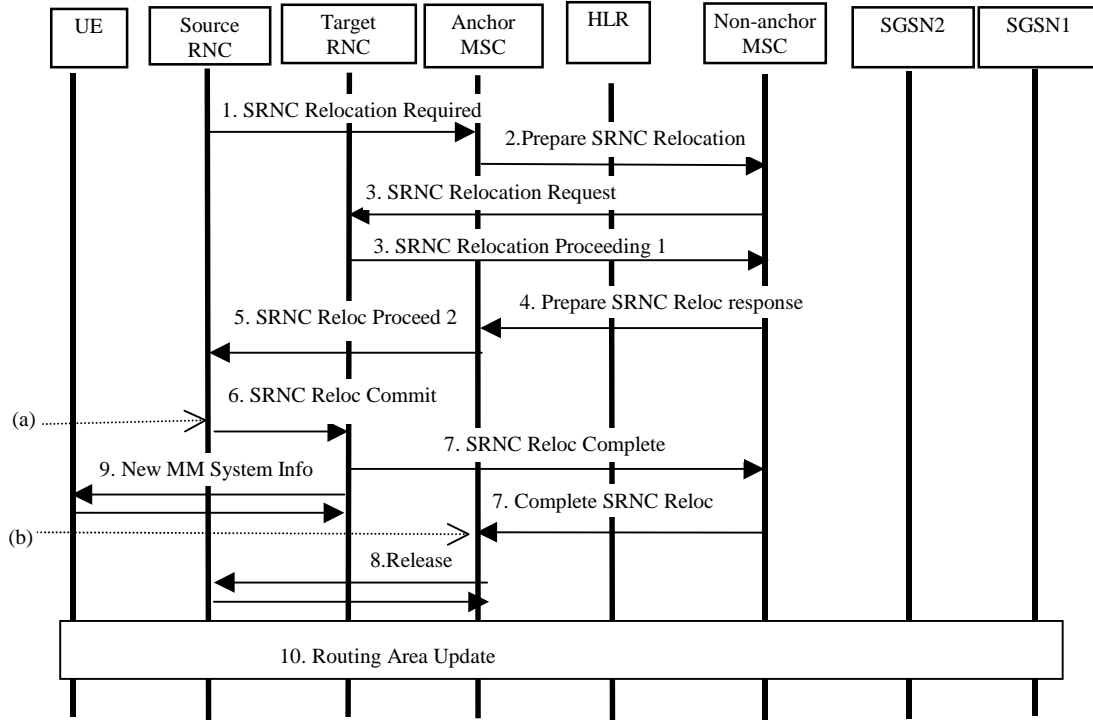
Figure 16 Interface information transfer for SRNS relocation when UE connected to 3G_MSC/VLR followed by location registration in new Routing Area.

1) UTRAN makes the decision to perform the Serving RNC relocation procedure. This includes decision on into which RNC (Target RNC) the Serving RNC functionality is to be relocated. The source SRNC sends SRNC Relocation required messages to the MSC. This message includes parameters such as target RNC identifier and an information field that shall be passed transparently to the target RNC.

2) Upon reception of SRNC Relocation required message the Anchor MSC (MSC1) prepares itself for the switch and determines from the received information that the SRNC relocation will (in this case) involve another MSC. The Anchor MSC will then send a Prepare SRNC Relocation Request to the applicable non-anchor MSC (MSC2) including the information received from the Source RNC.

3) The non-anchor MSC will send a SRNC Relocation Request message to the target RNC. This message includes information for building up the SRNC context, transparently sent from Source RNC (UE id., no of connected CN nodes, UE capability information), and directives for setting up Iu user plane transport bearers. When Iu user plane transport bearers have been established, and target RNC has completed its preparation phase, SRNC Relocation Proceeding 1 message is sent to the non-anchor MSC.

4) The Prepare SRNC Relocation Response that is sent from non-anchor MSC to Anchor MSC will contain the SRNC Relocation Proceeding 1 received from target RNC.

5) When the SRNC Relocation Proceeding 1 has been received in the Anchor MSC, the user plane transport bearers has been allocated the whole path between target RNC and Anchor MSC and the Anchor MSC is ready for the SRNC move, then the Anchor MSC indicates the completion of preparation phase at the CN side for the SRNC relocation by sending the SRNC relocation proceeding 2 message to the Source RNC.

6) When the source RNC has received the SRNC Relocation Proceeding 2 message, the source RNC sends a SRNC Relocation Commit message to the target RNC. The target RNC executes switch for all bearers at the earliest suitable time instance.

7) Immediately after a successful switch at RNC, target RNC (=SRNC) sends SRNC Relocation Complete message to the non-anchor MSC. This message is included by the non-anchor MSC in the Complete SRNC relocation message that is sent to the anchor MSC. Upon reception of this message, the Anchor-MSC switches from the old Iu transport bearers to the new ones.

8)   After a successful switch at the Anchor MSC, a release indication is sent towards the Source RNC. This will
      imply release of all UTRAN resources that were related to this UE.

9)   When the target RNC is acting as SRNC, it will send New MM System Information to the UE indicating e.g.
      relevant Routing Area and Location Area. Additional RRC information may then also be sent to the UE, e.g.
      new RNTI identity.

10)   When receiving new MM system information indicating a new Routing Area, the UE will in this case initiate a
      Routing Area update procedure towards the SGSN.

Before point (a), in Figure 16, the connection is established between UE and Anchor MSC via Source RNC.

After point (b), in Figure 16, the connection is established between UE and Anchor MSC via Target RNC and Non-
anchor MSC.

7.3.11.2.2 SRNS relocation (UE connected to a single CN node, 3G_SGSN) followed by Location Registration in new Location Area

This example shows SRNS relocation when source RNC and target RNC are connected to different 3G_SGSN. Figure
17 and Figure 18 illustrate the situation before respective after the SRNS relocation and location registration. Figure 19
illustrates the signalling sequence where each step is explained in the following list.
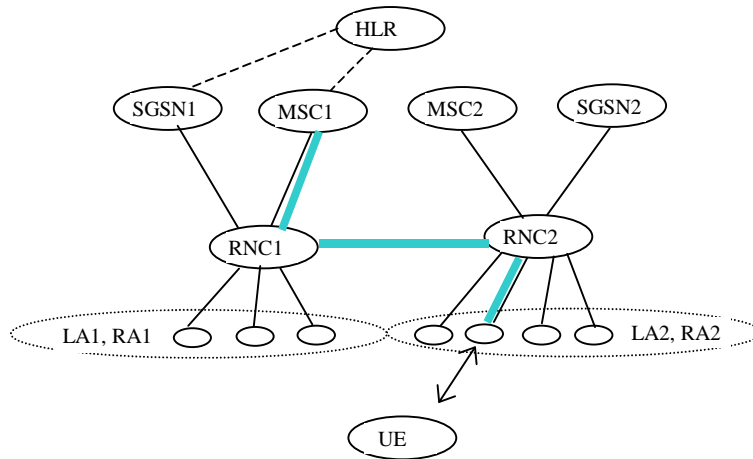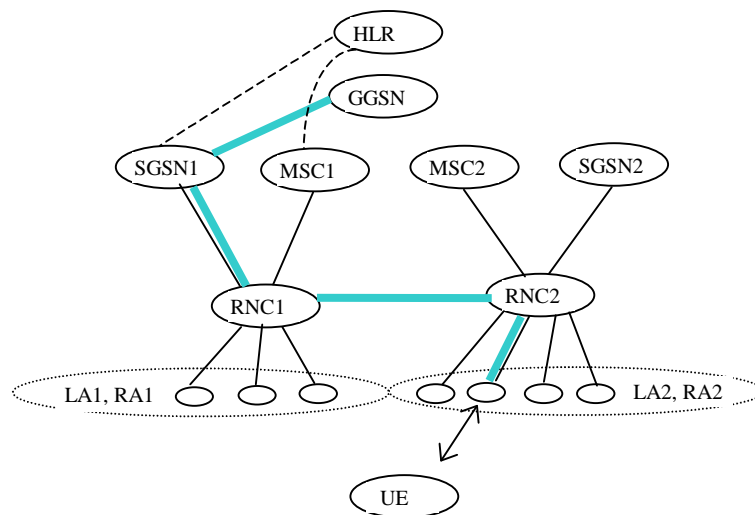

Figure 17 Before the SRNS relocation and location registration

Before the SRNS relocation and location registration the UE is registered in SGSN1 and in MSC1. The UE is in state
MM connected towards the SGSN1 and in state MM idle towards the MSC1. The RNC1 is acting as SRNC and the
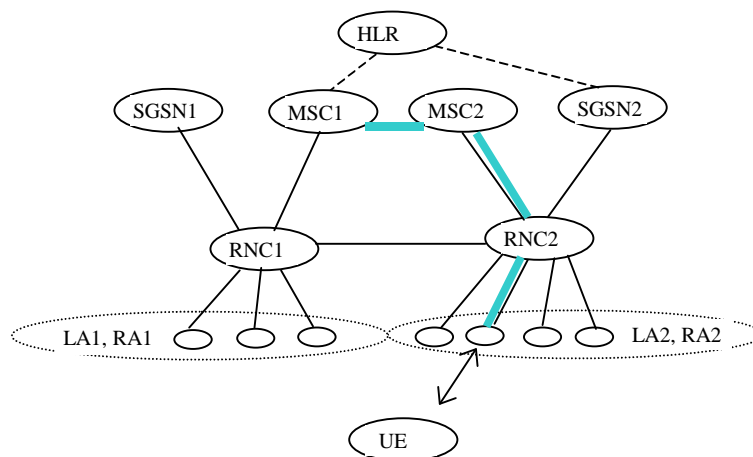RNC2 is acting as DRNC.
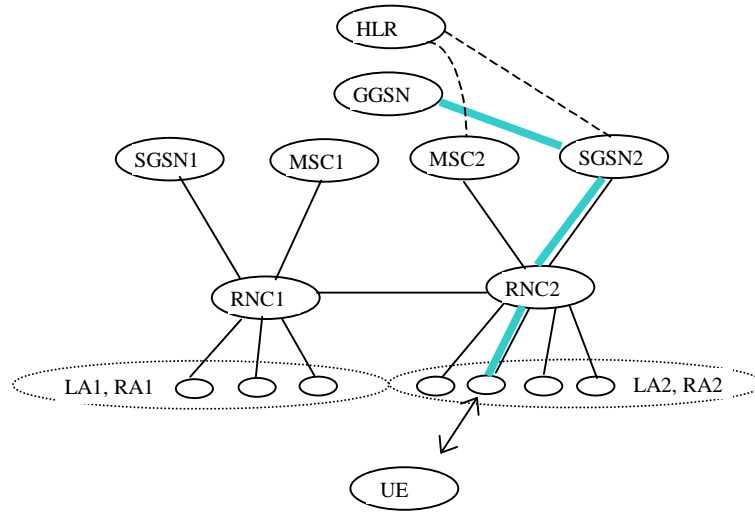
Figure 18 After the SRNS relocation and location registration

After the SRNS relocation and location registration the UE is registered in MSC2 and in SGSN2. The UE is in state MM connected towards the SGSN2 and in state MM idle towards the MSC2. The RNC2 is acting as SRNC.
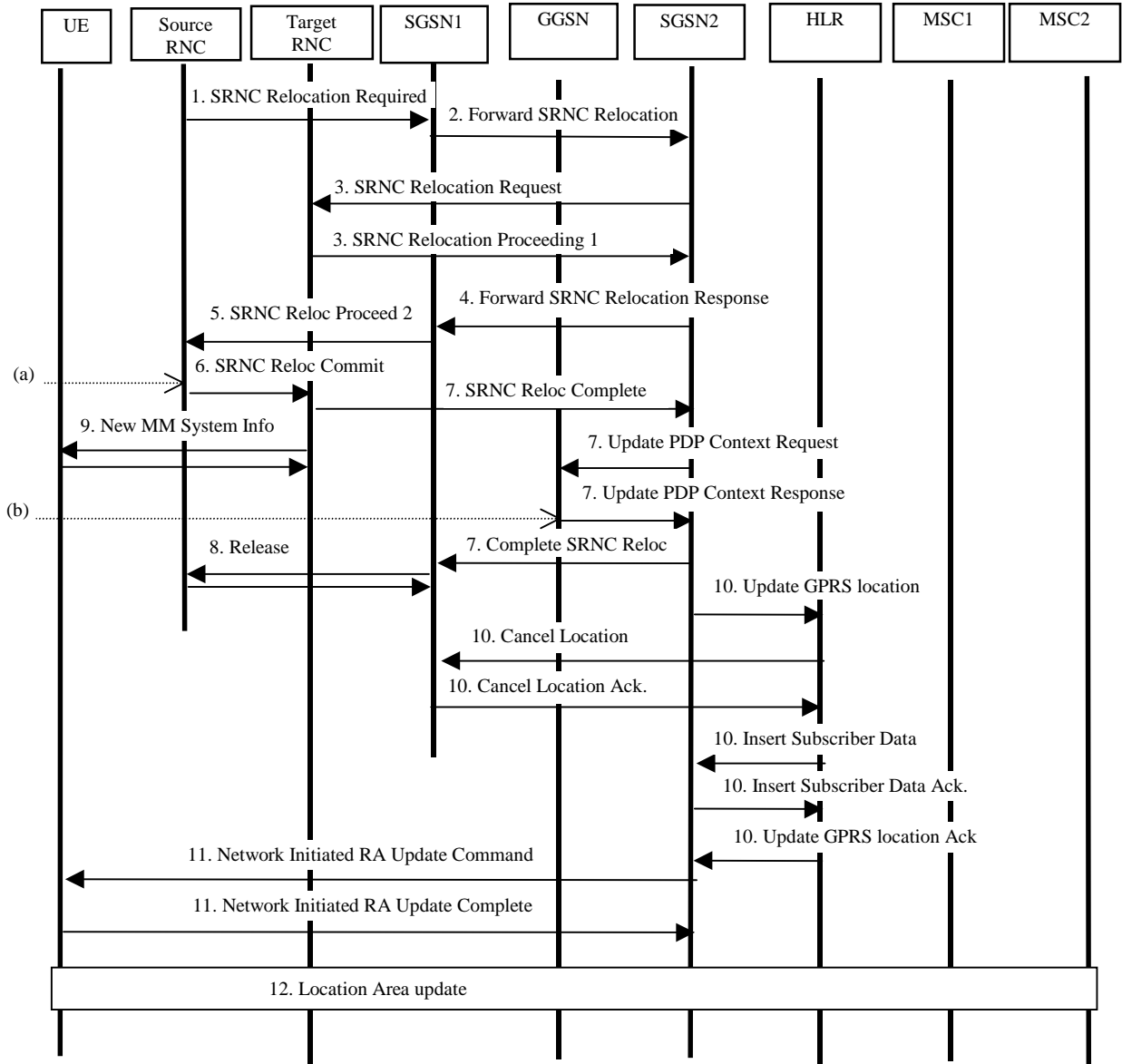
Figure 19 Interface information transfer for SRNS relocation update when changing SGSN area resulting in a change of registered location and followed by location registration in new Location Area.

1) UTRAN makes the decision to perform the Serving RNC relocation procedure. This includes decision on into which RNC (Target RNC) the Serving RNC functionality is to be relocated. The source SRNC sends SRNC Relocation required messages to the SGSN1. This message includes parameters such as target RNC identifier and an information field that shall be passed transparently to the target RNC.

2) Upon reception of SRNC Relocation required message the SGSN1 determines from the received information that the SRNC relocation will (in this case) result in change of SGSN.
The SGSN will then send a Forward SRNC relocation request to the applicable SGSN, SGSN2, including the information received from the Source RNC and necessary information for the change of SGSN (e.g. MM context, PDP context).

3) The SGSN2 will send a SRNC Relocation Request message to the target RNC. This message includes information for building up the SRNC context, transparently sent from Source RNC (e.g. UE id., no of connected CN nodes, UE capability information), and directives for setting up Iu user plane transport bearers.
When the Iu user plane transport bearers have been established, and target RNC completed its preparation phase, SRNC Relocation Proceeding 1 message is sent to the SGSN2.

4)   When the traffic resources between target RNC and SGSN2 has been allocated and the SGSN2 is ready for the SRNC move, then the Forward SRNC Relocation Response is sent from SGSN2 to SGSN1. This message indicates that necessary resources have been allocated for the SRNC relocation.

5)   When the Forward SRNC Relocation Response has been received in the SGSN1, the SGSN1 indicates the completion of preparation phase at the CN side for the SRNC relocation by sending the SRNC Relocation Proceeding 2 message to the Source RNC.

6)   When the source RNC has received the SRNC Relocation Proceeding 2 message, the source RNC sends a SRNC Relocation Commit message to the target RNC. The target RNC executes switch for all bearers at the earliest suitable time instance.

7)   Immediately after a successful switch at RNC, target RNC (=SRNC) sends SRNC Relocation Complete message to the SGSN2. Upon reception of this message, the SGSN2 updates the GGSN with a Update PDP Context Request including the new SGSN address. The GGSN will then update the PDP context and return Update PDP Context Response. The SGSN will also send a Complete SRNC Relocation towards the SGSN1.

8)   At reception of the Complete SRNC Relocation, SGSN1 will send a release indication towards the Source RNC. This will imply release of all UTRAN resources that were related to this UE.

9)   When the target RNC is acting as SRNC, it will send New MM System Information to the UE indicating e.g. relevant Routing Area and Location Area. Additional RRC information may then also be sent to the UE, e.g. new RNTI identity.

10) The SGSN2 informs the HLR of the change of SGSN by sending Update GPRS location (IMSI, new SGSN address etc.) to the HLR. The HLR cancels the context in the old SGSN, SGSN1, by sending Cancel Location (IMSI). The SGSN1 removes the context and acknowledges with Cancel Location Ack. The HLR sends Insert subscriber data (IMSI, subscription data) to the SGSN2. The SGSN2 acknowledges with Insert Subscriber Data Ack. The HLR acknowledges the Update GPRS location by sending Update GPRS Location Ack to the SGSN2.

11) At reception of Insert subscriber data from HLR, the SGSN2 will initiate the update of MM information stored in the UE. This is done by sending Network Initiated Routing Area Update Command to the UE. This message will include new RAI, and possible also new P-TMSI. When the UE has made necessary updates it answers with Network Initiated Routing Area Update Complete.

12) When receiving new MM system information indicating a new Location Area, the UE will, in this case, initiate a Location Area update procedure towards the MSC2. This implies that the Location Area update will be performed in parallel to the above indicated activities related to the SGSN side of the Core Network.

Before point (a), in Figure 19, the connection is established between UE and GGSN via Source RNC and SGSN1.

After point (b), in Figure 19, the connection is established between UE and GGSN via Target RNC and SGSN2.

7.3.11.3   Comparision between UMTS and GSM

For the PSTN/ISDN domain, the proposed UMTS MM concept is in principle identical to the GSM MM.

For the IP domain, the differences between the proposed UMTS MM concept and the GSM GMM are more extensive, such as:

a)   "Cell update" is moved from GMM level in GSM to RRC level in UMTS.

b)   "Routing area update" in GSM GMM-standby state is moved from GMM level in GSM to RRC level in UMTS and corresponds to "URA update".

c)   A new case when "Routing area update" is performed towards 3G_SGSN is introduced in the UMTS PS-IDLE state.

d)   A UMTS PS-CONNECTED state is introduced and in this state the UE mobility towards the CN will be handled by UTRAN-CN procedures, i.e. not on MM level.

Figure 25 provides illustration of the above bullets.
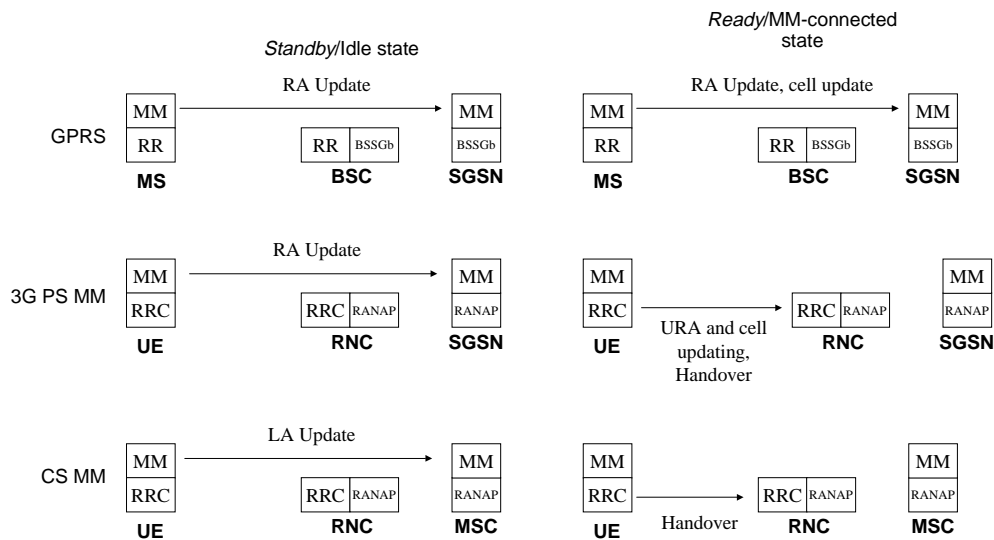
Figure 20 The states written in italics correspond to those defined in GSM with GPRS.

7.3.11.3.1   PS -idle state

The RA update procedure is utilized to update the whereabouts of the UE into SGSN. The updating into SGSN takes place irrespectively of the CS MM state in MSC.

7.3.11.3.2   PS -connected state

The URA and cell updating and handover procedures presented in Figure 25 are based on UMTS YY.03 [2]. In brief, the aim in [2] is to introduce functionality that caters for the same functionality as standby/ready in GPRS. The RRC shall be designed in such a fashion, which allows the state of the RRC connection to define the level of activity associated to a packet data connection. The key parameters of each state are the required activity and resources within the state and the required signalling prior to the packet transmission. The similar functionality in GPRS is offered via standby/ready at MM level.

The cell update and URA update between UE and RNC are used when the UE is in RRC common channel state, i.e., when the above mentioned parameters allow to scale down the resources reserved for the UE (for a more detailed description on this, see [2]). For example, the purpose of the cell update procedure is to allow the UE to inform its current location in the corresponding RRC state. According to [2] the cell update procedure replaces handover in the corresponding RRC substate.

To summarize, the RRC procedures proposed by [2] allow the CN MM to be independent of the actual activity. This is a significant deviation from GPRS MM, which is closely related to the activity in terms of implementing standby and ready functionality at MM level. Another significant deviation from GPRS is the introduction of the handover procedures for connections supporting traffic into IP domain (in RRC cell connected state, see [2]).

7.3.11.4 Issues for further study

List of issues that are for further study related to this chapter and is the following:

a) More details are required with regards to the differences with regards to the "IP-domain" MM compared to GPRS MM, especially considering roaming and handover to/from UMTS to GSM/GPRS.

b) More details should be provided with regards to the logical relations between UE-CN and UTRAN-CN, and how these relate to the physical interconnection between UTRAN and the CN nodes(s), namely whether one logical/physical Iu can be used to interconnect the UTRAN with the CN.

c) It should be clarified whether this approach allows for the possibility to use a common signalling connection from MSC and/or SGSN to the HLR.

7.3.12 Combined update towards the HLR for a combined 3G-(MSC/VLR+SGSN) configuration

7.3.12.1 Motivation

In order to optimise the signalling load within the network, reduce operating and maintenance costs and creating the possibility to combine cs and ps handover it is essential to open the door in the specifications for combined 3G-(MSC/VLR+SGSN) solutions.

7.3.12.2 Technical description

For the area concept discussed for the time being, four different cases have to be distinguished:

1. change of UTRAN Registration Area (URA) within the same Routing Area (RA)

2. change of URA and RA within the same Location Area (LA)

3. change of URA, RA, or LA within the same node

4. change of URA, RA, or LA, and node

For a combined 3G-(MSC/VLR+SGSN) node only in case 4 the UE's HLR has to be updated. If the UE is idle mode for the packet and circuit switched traffic a combined 3G-(MSC/VLR+SGSN) node will run the location update procedure jointly for the UE's cs and ps domain resulting in one combined location update message, see Figure 3.
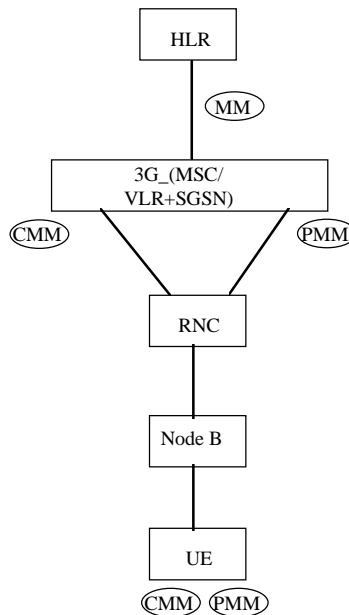
Figure 21 Combined MM Instance For a Combined 3G-(MSC/VLR+SGSN) Node

Split nodes may have to run one specific location update procedure for any of the two domains resulting in two separate location update messages, see Figure 4.
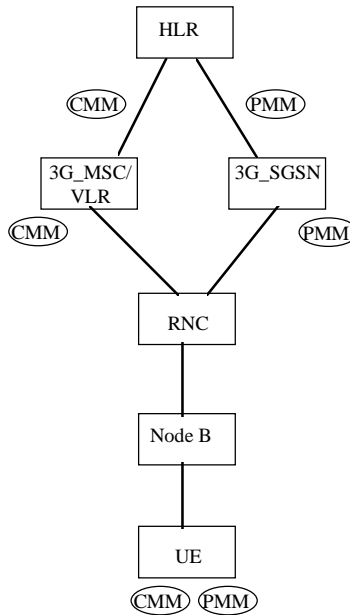
Figure 22 Split MM Instances for Separate Nodes

7.3.12.3 Requirements on UTRAN

The provision of location information by the UE to the core network must be independently of whether the 3G-MSC/VLR and 3G-SGSN are implemented as separate entities or as a combined node. It shall be possible to use a combined update procedure between serving node and HLR irrespective of the update procedure used between the UE and the serving node.

7.3.12.4 List of MAP services for location management between the HLR and MSC-VLR/SGSN for GSM/GPRS

Table 1 shows the MAP services used for location management between the SGSN and MSC/VLR and the HLR as defined in GSM/GPRS release 98.

MAP service	Comment
MAP_UPDATE_LOCATION service	Updates VLR and MSC number in the HLR
MAP_UPDATE_GPRS_LOCATION service	Updates SGSN number and address in the HLR
MAP-INSERT-SUBSCRIBER-DATA service	Inserts subscriber data for GSM or GPRS
MAP_SEND_AUTHENTICATION_INFO service	To send authentication triplets to VLR or SGSN
MAP_CANCEL_LOCATION service	Cancels location in VLR or SGSN
MAP_PURGE_MS service	Marks user as unreachable in HLR. Common service for both GSM and GPRS

Table 1: List of Location management services between the HLR and MSC/VLR and SGSN

From the above table, it is clear that only minor modifications are required to MAP services between the MSC/VLR and SGSN and the HLR. A new service combining the MAP_UPDATE_LOCATION and MAP_UPDATE_GPRS_LOCATION services will need to be defined. All other services are common for both GSM and GPRS and can be used with minor modifications in the "conditional" parameter list.

7.3.12.5 Signalling procedures for combined update towards HLR

7.3.12.5.1 Combined attach case where the previous attach was towards 2 CN elements
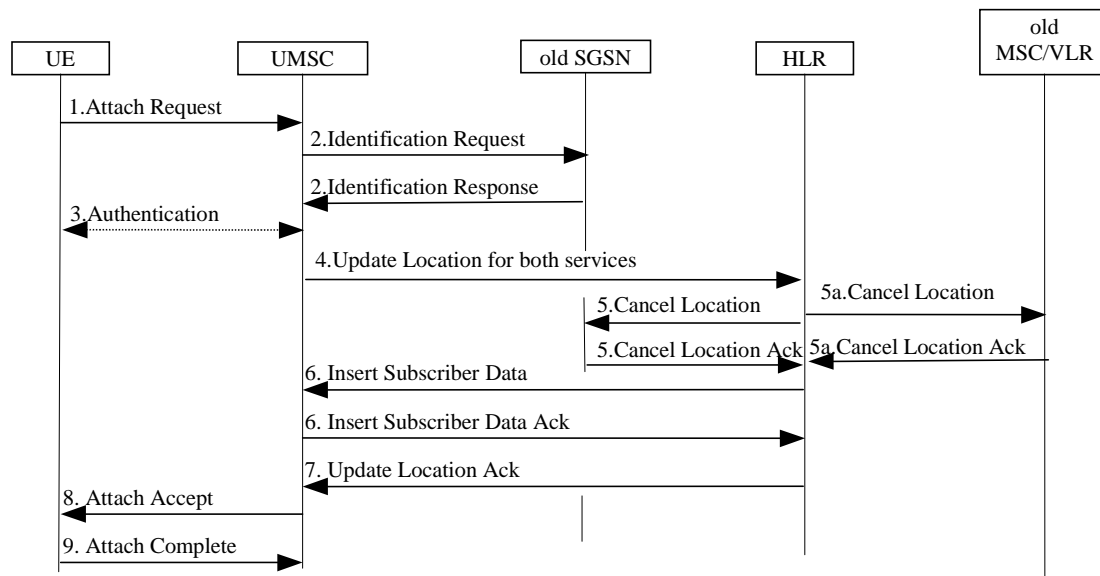
Figure 23 Combined attach procedure when the Ms moves froom 2 CN element to a UMSC

1)   The UE initiates the attach procedure by the transmission of an Attach Request (IMSI or P-TMSI and old RAI, Attach Type, old P-TMSI Signature) message to the UMSC. Attach Type indicates which type of attach that is to be performed, i.e., PS attach only, CS attach only, or combined attach (the example given is for combined attach).

2)   If the UE identifies itself with P-TMSI and the 3G-SGSN/UMSC has changed since detach, the new UMSC sends an Identification Request (P-TMSI, old RAI, old P-TMSI Signature) to the old SGSN to request the IMSI. The old SGSN responds with Identification Response (IMSI, Authentication Triplets). If the UE is not known in the old SGSN, the old SGSN responds with an appropriate error cause. The old SGSN also validates the old P-TMSI Signature and responds with an appropriate error cause if it does not match the value stored in the old SGSN.

3)   The authentication functions are optional and may be used for example if P-TMSI signature authentication was not successful.If the UMSC number has changed since the detach, or if it is the very first attach, routeing/location area update procedures are executed:

    4) The UMSC sends a Combined Update Location (UMSC Number, UMSC Address, IMSI) to the HLR.

    5) The HLR sends Cancel Location (IMSI, Cancellation Type) to the old SGSN and MSC. The old SGSN and MSC acknowledges with Cancel Location Ack (IMSI).

    6) The HLR sends Insert Subscriber Data (IMSI, PS and CS subscription data) to the new UMSC. The new UMSC validates the UE's presence in the (new) RA. If all checks are successful then the UMSC constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

7)   The HLR acknowledges the Update Location message by sending an Update Location Ack to the UMSC. If the Update Location is rejected by the HLR, the UMSC rejects the Attach Request from the UE with an appropriate cause.

8)   The UMSC sends an Attach Accept (P-TMSI, TMSI, P-TMSI Signature) to the UE.

9)   If P-TMSI or TMSI was changed, the UE acknowledges the received TMSI(s) with Attach Complete
          (P-TMSI, TMSI).

If the Attach Request cannot be accepted, the UMSC returns an Attach Reject (IMSI, Cause) message to the UE.

7.3.12.5.2 Combined location/routing area update where the previous LA/RA belonged to a 2 CN element
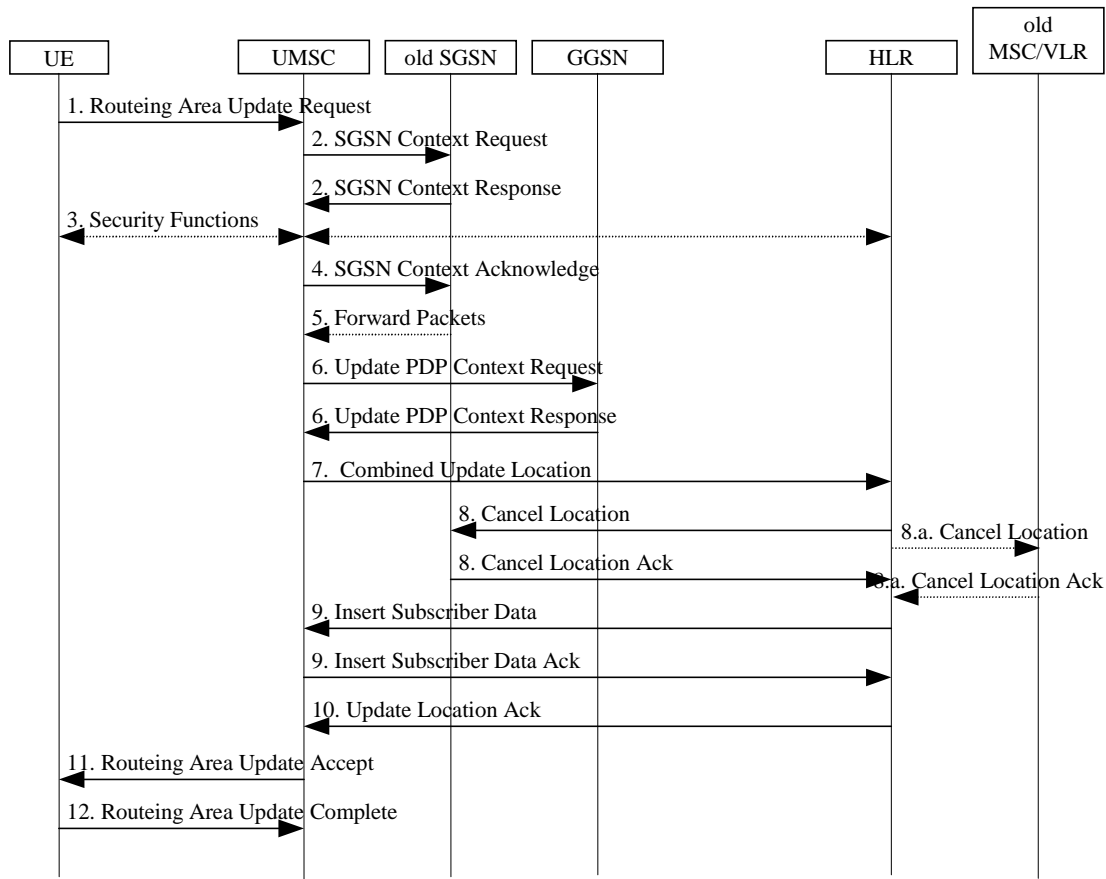
Figure 24 Combined LA/RA update when the MS moves from 2 CN element to UMSC

1)   The UE sends a Routeing Area Update Request (old RAI, old P-TMSI Signature, Update Type) to the new
          UMSC. Update Type example given here is for combined RA / LA update.

2)   The new UMSC sends SGSN Context Request (old RAI, P-TMSI, old P-TMSI Signature, New UMSC
          Address) to the old SGSN to get the MM and PDP contexts for the UE. The old SGSN validates the old P-TMSI
          Signature and responds with an appropriate error cause if it does not match the value stored in the old SGSN.
          This should initiate the security functions in the new UMSC.

3)   Security functions may be executed. These procedures are defined in subclause "Security Function".

4)   If the user has at least one activated PDP context, then the new UMSC shall send an SGSN Context
          Acknowledge message to the old SGSN. This informs the old SGSN that the new UMSC is ready to receive data
          packets belonging to the activated PDP contexts.

5)   The old SGSN starts tunnelling of buffered N-PDUs to the new UMSC.   However, the possibility of this
          happening is remote since the UE is in MM-idle indicating that it was not in active communication.

6) The new UMSC sends Update PDP Context Request to the GGSNs concerned. The GGSNs update their PDP context fields and return an Update PDP Context Response (TID).

7) The new UMSC informs the HLR of the change of SGSN/MSC by sending Combined Update Location (UMSC Number, UMSC Address, IMSI) to the HLR.

8) The HLR sends Cancel Location (IMSI, Cancellation Type) to the old SGSN and MSC. The old SGSN acknowledges with Cancel Location Ack (IMSI).

9) The HLR sends Insert Subscriber Data (IMSI, PS and CS subscription data) to the new UMSC. The new UMSC validates the UE's presence in the (new) RA. If due to regional subscription the UE is rejected, the UMSC rejects the Attach Request with an appropriate cause and returns an Insert Subscriber Data Ack (IMSI, UMSC Area Restricted Due To Regional Subscription) message to the HLR. If all checks are successful then the UMSC constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

10) The HLR acknowledges the Update Location by sending Update Location Ack (IMSI) to the new UMSC.

11) The new UMSC validates the UE's presence in the new RA. If due to regional, national or international restrictions the UE is not allowed to attach in the RA or subscription checking fails, then the UMSC rejects the routeing area update with an appropriate cause. If all checks are successful then the new UMSC establishes MM and PDP contexts for the UE. The new UMSC responds to the UE with Routeing Area Update Accept (P-TMSI, TMSI, P-TMSI Signature).

12) The UE confirms the reallocation of the TMSIs by sending Routeing Area Update Complete to the UMSC.

8. 0 UMTS Concepts

Section 8 contains concepts that are considered as stable within SMG12 and no further input is expected but it should also be noted that consensus could not be reached on their use within UMTS.

8.1 Reduction of UMTS signalling

8.1.1 GLR Concept

The benefits of the Gateway Location Register (GLR) are:

- reduction in signaling traffic between networks.

- potential enhancements to mobile terminated call handling

8.1.1.1 Overview of the GLR Concept

The GLR is a node between the VLR and the HLR, which may be used to optimize the handling of subscriber location data across network boundaries.

In Figure 25, the GLR interacts with HLRa and VLRb for roamers on Network B. The GLR is part of the roaming subscriber's Home Environment. When a subscriber to HLRa is roaming on Network B the GLR plays the role of an HLR towards VLRb and the role of a VLR towards HLRa. The GLR handles any location change between different VLR service areas in the visited network without involving HLRa.
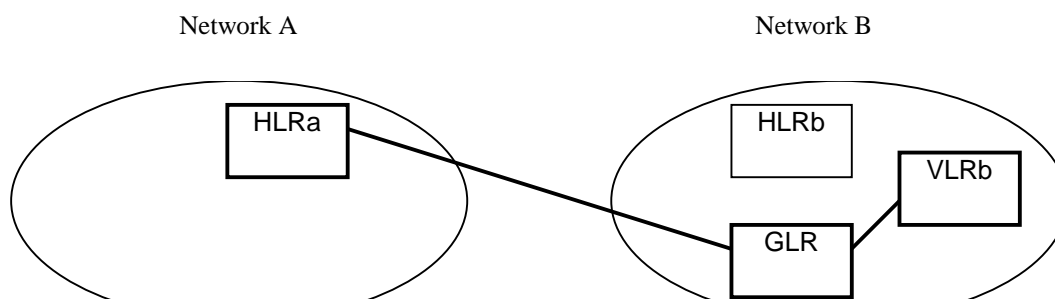
Figure 25 GLR Overview

The sequence of events when the subscriber roams to network B is as follows:

- VLRb sends the registration message to HLRa via the GLR, (i.e. HLRa stores the GLR's SCCP address and the GLR stores VLRb's SCCP address).

- HLRa returns the subscriber profile data

- The subscriber profile is stored in the GLR and VLRb

As the roaming subscriber moves between VLRs in network B, then the GLR is updated, but no message is sent to HLRa, therefore the number of messages between Network A and Network B is reduced. The reduction in signaling traffic is a significant benefit when the two networks are far apart, e.g. between Europe and Japan.

8.1.1.2 Applications of the GLR

In addition to reducing the amount of mobility related signalling between networks, the GLR's function might also be extended to other aspects. These include the following:

- Enhancements for mobile terminated call handling

- Support for the Virtual Home Environment of a roaming subscriber

- Reduction of CAMEL signalling traffic between the visited and home network

- Hiding local variations in signalling between networks

Further study is needed on these issues

8.2 Alternate Access technologies to UTRAN

BRAN Access

The evolved GPRS network should allow for various radio access networks. As stated in [UMTS 23.01], a modular approach in UMTS evolution is recommended. This is also in line with the recommendation from GMM. Thus, the infrastructure domain, which encompasses the core network domain and the access network domain, allows for different access techniques/networks to be used. This scenario focuses on EP BRAN HIPERLAN 2 as a complement to GSM BSS and UTRAN in order to provide broadband data services in hot spot environments.

ETSI Project BRAN (Broadband Radio Access Networks) is developing specifications for broadband wireless access systems that support data rates around 25 Mbit/s for several applications. The primary focus for HIPERLAN 2 is to provide short range wireless broadband access with controlled quality of service for use within buildings and on-campus using unlicensed radio spectrum in the 5 GHz band. HIPERLAN 2 shall provide a range of 30-50 m in a typical indoor environment and up to 150-200 m in a typical outdoor environment.

The HIPERLAN 2 specifications are expected to be finalised during 2000, hence it will be possible to introduce BRAN access in UMTS phase 1.

8.2.1 Advantages of attaching HIPERLAN 2 to UMTS

- Provide UMTS with a complementary access technology for broadband data services for indoor and hot spots environments

- UMTS mobility infrastructure enables roaming also for HIPERLAN 2 terminals

- Easier multi-mode UMTS/HIPERLAN 2 service integration, enables e.g. network support for a one number service and the use of a common service platform

- UMTS subscriber management may be reused for HIPERLAN 2

- Enables the reuse of investments in core network technologies.

8.2.2 HIPERLAN 2 UMTS Interworking

UMTS will incorporate a new generic radio access network, the UMTS Radio Access Network (URAN). The URAN may include several different realisations, of which the UTRAN (UMTS Terrestrial Radio Access Network) is one. The Iu reference point forms the boundary between URAN and the UMTS core network. By connecting HIPERLAN 2 to the Iu interface, HIPERLAN 2 will form a complimentary realisation of the URAN concept for broadband data services. UMTS interworking will provide HIPERLAN 2 with roaming support using the UMTS mobility infrastructure.
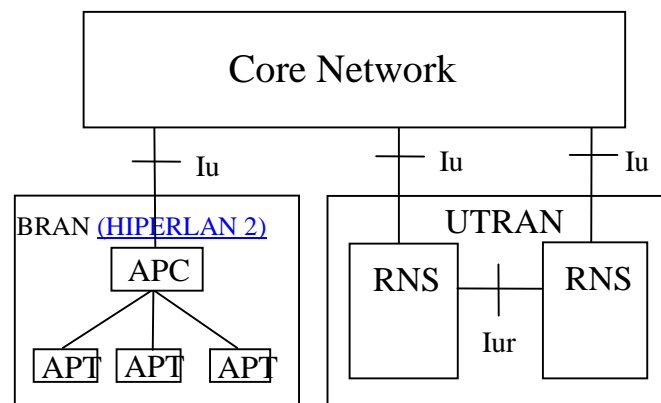
Figure 26: HIPERLAN 2 UMTS interworking.

A HIPERLAN 2 realisation of URAN should provide the same logical interface to the higher layers (i.e. layers belonging to the non-access stratum) as UTRAN. Hence, no changes in higher layers should be required. UMTS authentication, security and location management can be used over HIPERLAN 2. UMTS bearer setup requests should be mapped to the corresponding HIPERLAN 2 DLC connection. A USIM (User Service Identity Module) may be needed in a BRAN terminal supporting UMTS interworking. Handovers within a HIPERLAN 2 subsystem should be invisible to the core network. Handovers between UTRAN andHIPERLAN 2, in case of dual mode terminals, should be supported via the core network.

8.2.3 Related Actions

The same protocols over the Iu interface should be used for both UTRAN and HIPERLAN 2. However, some impact of connecting a broadband access network, capable of bit rates in the order of 100 Mbit/s, can be expected. Therefore the Iu must be flexible and future proof. Guidance and co-operation with EP BRAN on these matters should be sought.

9   Key issues

{Editors note: These key issues have arisen from the scenario work, it is agreed within SMG12 that the focus should be on solving these key issues, Once these issues have become relatively stable, they are moved to the Section 7 or 8~~8~~ or removed from this document}. Study of these items is ongoing.

9.1   Core network transport

- L1 and L2 technologies

- Signalling protocols

- How to use ATM?

- Nx64k transport

9.2   Core network layer 3

- L3 technologies

- GTP vs. IP-in-IP tunneling

In UMTS/GPRS, it should be possible for operators to use different packet switching protocol (e.g. ATM-SVC) under single GTP standard.

Between GSNs GTP uses UDP/IP (or TCP/IP) for addressing regardless whether IP routing or ATM-SVC switching is used. The use of ATM-SVC will not impact on GTP standardisation
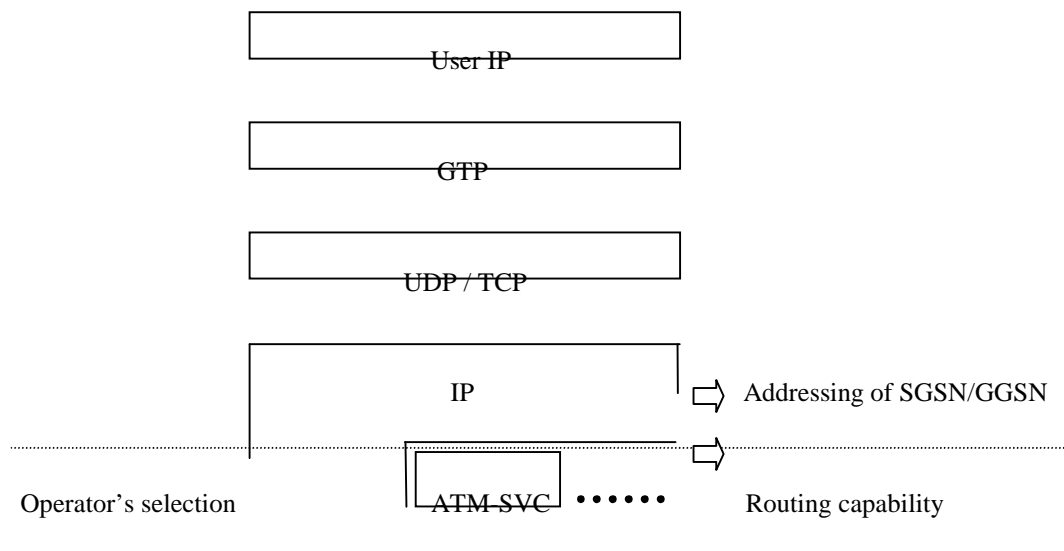
9.3 Benefits of the Gs interface applied to UMTSThe Gs interface defined within GSM/GPRS provides a number of benefits to a GSM/GPRS operator [03.60]. These include: combined attach/detach procedures, combined location/routing area updates, paging of CS connection via the SGSN, identification procedures, MM information procedures. The main aims of these include saving of GSM/GPRS radio resources, harmonised security procedures and reduction of MS battery consumption.

As GSM operators roll out GPRS and as the numbers of mobiles increase the benefits of the Gs interface to the network operator will increase as the percentage of GPRS enabled mobiles grows. GSM/GPRS operators with mature networks will also be looking to roll out UMTS using evolved CN infrastructure, they will also be looking to apply the benefits of the Gs interface reaped for GSM to UMTS. Many of the capabilities of the Gs interface will be applicable to UMTS

(such as combined updates, combined attach and MS/Ue information procedures), this will save on radio resource usage. The presence of the MSC-GSN interface will also offer the opportunity for developments to ease seamless service support between CS and PS platforms (such as SoLSA and Camel).

In the future, network operators who have incorporated Gs functionality into their networks will be looking to connect UTRAN to their GSM/GPRS Core Networks with minimal changes (excepting those for service development, network and radio optimisation, network evolution and flexibility), thus the Gs interface should be maintained and enhanced for UMTS.

The Gs interface also offers opportunities for suppliers and operators regarding integrated MSC/GSN products (which may support internal proprietary Gs functionality as well as standardised MSC-GSN functionality). Operator's networks which have separated MSC/GSN nodes will be able to add integrated nodes into their GSM/GPRS/UMTS networks (and vice versa), depending upon the MM solutions developed for UMTS this could enable combined updates to be performed between (Gs supporting) integrated and separated nodes. If the Gs interface is not present operators will not be able to optimise resource between (integrated or separated) nodes.

9.3.1 Periodic updates

9.3.2 Why do we have Periodic updates

Periodic updates are within the network to increase the efficiency of the CN while also increasing the quality of service perceived by calling parties to mobiles. The periodic timer is set within the CN node to a figure which enables absent mobiles to have their (VLR based) information removed after the timer expires. People calling mobiles which are registered as 'detached' (either implicitly or via periodic expiry) will receive faster treatment of the call in the CFNRc case or 'Not been possible to connect your call' RANN case as the mobile is not paged by the network.

9.3.3 Support of periodic updates in UMTS

One of the current proposals for SRNS relocation [1, incl: section 9.3.4, 2] propose that when in CMM connected mode (PMM idle) or PMM connected (CMM idle) the relevant location/routing updates to the (idle) CN are perfomed while in RRC connected mode.

For periodic updates the UE may be RRC connected (know to the UTRAN as 'active') when the (UE based) periodic timer is due to expire, the (idle) CN node will also have a timer about to expire and be ready to detach the UE.

If the methodology of [1, Section 9.3.4] is followed a location update will be performed within the same RRC connection to the (MM idle state) CN node to re-set the periodic timer.

9.3.4 Impact upon UMTS

The impact upon UMTS of this is that the UTRAN, UE and one CN node have an active session ('xMM connected) in place with accurate knowledge of the (periodic) attached/detached status of the UE. It is a waste of (valuable) radio resource for the UE to perform a LA/RA update purely to reset the periodic timer in the (idle) CN node: this also contradicts working assumption [1, section 11].

As UMTS is envisaged as a mass market system supporting very large numbers of mobiles within the network, many of these could potentially have very long (i.e. all day) duration (but low packet volume) Packet sessions (as per GPRS). It is folly to consider additionally loading the radio resource to update the (periodic) detach status of the mobile on the CN side of the radio interface when elements on the CN side of the radio interface already know the status of the mobile.

9.4 Authentication

9.5 Management of ciphering keys

9.5.1 Cipher Mode Control – 2MM concept

The assumptions in this section is based upon the assumption that ciphering in performed between UE and RNC.

It is assumed that in UMTS the ciphering key and the allowed ciphering algorithms are supplied by CN domains to the UTRAN usually in the beginning of the connection. Receipt of the ciphering command message at the UTRAN will cause the generation of a radio interface ciphering command message and, if applicable, invoke the encryption device and start data stream ciphering. The CN domain is noted if the ciphering is executed successfully in the radio interface and the selected ciphering algorithm.

When new connection is established from other CN domain, which is not having any connection to the UE, the new CN domain also supplies the ciphering key and the ciphering algorithms allowed to use to UTRAN in the beginning of the connection. This is due to the fact CN domains are independent from each other.

9.5.1.1 One ciphering key used in UTRAN

If it is assumed that only one ciphering key and one ciphering algorithm are used for all connections, this leads to a situation, in which there are two ciphering keys supplied from CN domains and only one of them is used.

To handle this situation, UTRAN must select either one of the ciphering keys. If there are no differences between the ciphering requirements[1] requested by two CN domains then, e.g., the first ciphering key and the algorithm is maintained (see Figure 27).
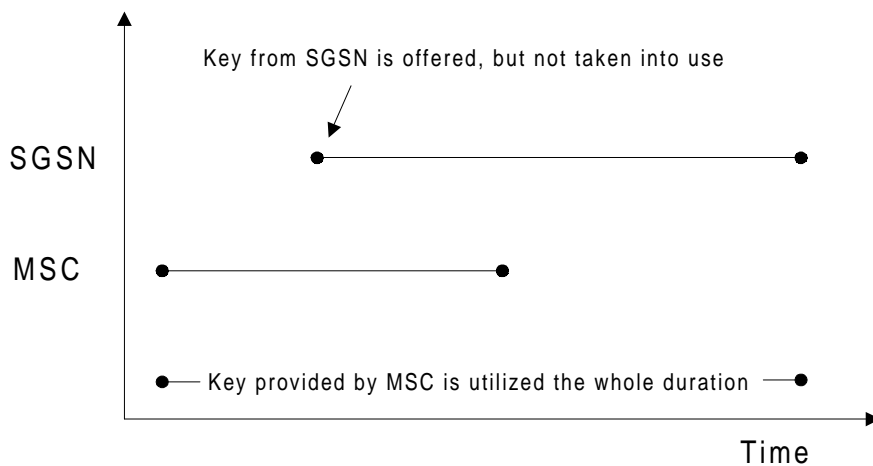
Figure 27. One ciphering key use in the UTRAN

As a result of the selection of the ciphering key between two different CN domains (if both CN domains have active connection(s) to the UE) either one or both of the CN domains do not know the present ciphering key used for the connection(s). Only UTRAN and UE know the present ciphering key used.

Further, if the case described in figure 1 is still considered and if after the MSC connection is released, but before SGSN connection is released, a new connection from MSC is established, the MSC may initiate a new authentication resulting in a new MSC ciphering key supplied to UTRAN. In this case, the UTRAN may follow the same key selection approach as it used previously, i.e., the first ciphering key is maintained[2].

9.5.1.2 Multiple ciphering keys used in UTRAN

It may be required to use more than one ciphering key for different radio access bearer, e.g., user plane bearers associated to one CN domain are ciphered by the ciphering key supplied by the associated CN domain. However, in the control plane only one ciphering key is used and therefore in the control plane there must be co-ordination between ciphering keys supplied by CN domains.

---

[1] E.g. a requirement for more efficient ciphering algorithm that is currently used for the connection(s).

[2] The change of used ciphering key during an active RRC connection is considered as a further study item.

The coordination in the control plane is similar to what is presented for one ciphering key used in UTRAN option (ch. 2.1). In the control plane, UTRAN must select either one of the ciphering keys supplied from CN domains if both CN domains are active. The change of the used ciphering key in the control plane during active RRC connection is for further study.

9.5.1.2 Serving RNC relocation and ciphering

In GSM, when inter-BSC handover is performed, MSC sends the ciphering key and allowed algorithms to the target BSC in the BSSMAP HANDOVER REQUEST message. In GPRS, because the SGSN performs the ciphering, the inter-BSC handover does not cause any need for the ciphering key management.

For UMTS, the GSM approach is not applicable on the serving RNC (SRNC) relocation, because CN domains do not necessary know the present ciphering key(s) used as it is described in the chapter 2.

It is recommended that the ciphering key(s) or a relevant information indicating used ciphering key(s) is transferred in the transparent UTRAN information field from the source RNC to the target RNC in the RANAP SRNC RELOCATION REQUIRED and RANAP SRNC RELOCATION REQUEST messages (see Figure 28.). In this way the present ciphering key(s) is transferred to the target RNC.
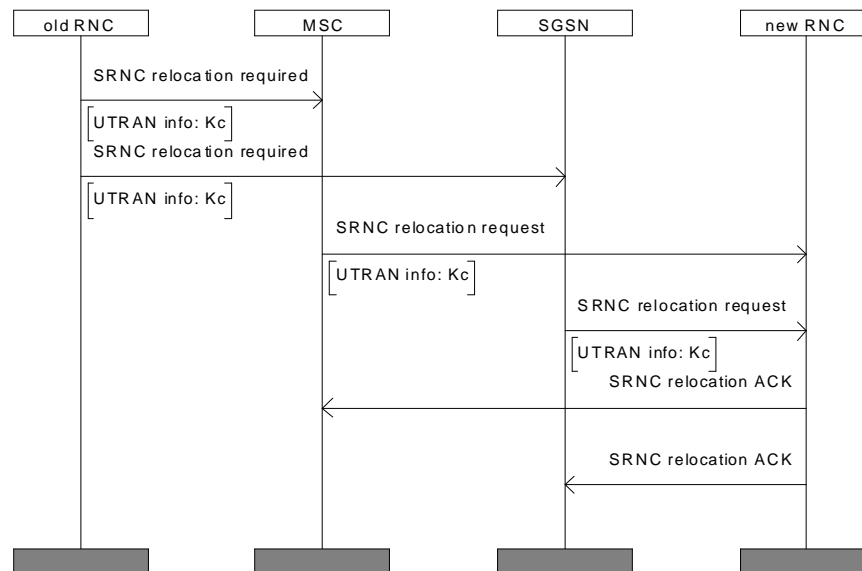
Figure 28. The ciphering key transfer in SRNC relocation procedure (one ciphering key)

9.5.2 UMTS-GSM handover

In the handover from UMTS to GSM, the ciphering key cannot be transferred transparently like it is proposed for UMTS. The CN has to build the BSSMAP HO REQUEST message, having the ciphering key from the MSC. 2G-SGSN receives its ciphering key from the old 3G-SGSN via Gn-interface as it is done in GPRS.

If the ciphering keys used in UMTS are different compared to GSM, e.g., the ciphering key length is different, both MSC and SGSN ciphering keys must be changed in UMTS-GSM handover. This type of interoperation is left for further study in this paper.

9.5.3 Interworking with 2g-MSC

In GSM, the A-interface BSSMAP [2] supports a transparent field in the BSSMAP HO REQUIRED and HO REQUEST messages, which allows to utilize the proposed solution also for GSM CN connected to the UTRAN.

9.6 Mobile IP in UMTS

9.6.1. Mobility Support

The possibility of combining different mobility handling systems should be considered. MAP, as being a widely spread protocol would form the basis for mobility handling in the evolution scenarios, but the combination of different mobility handling systems should be supported. As an example, the use of MobileIP, as a means to support discrete mobility, in combination with MAP subscriber handling, authorisation etc should be supported. In that case Mobile IP would be used to handle discrete mobility in between access networks, whereas GSM/GPRS would be used for handling of subscriber data, charging mechanisms etc. Thus, Mobile IP would handle roaming and possibly handover between radio access networks (UTRANs), whereas the GPRS SGSN node −enhanced to include also some IP functionality − would be used for mechanisms such as authorisation and handling of encryption keys.

9.6.2 Mobile IP

A single generic mobility handling mechanism that allows roaming between all types of access networks would allow the user to conveniently move between fixed and mobile networks, between public and private as well as between PLMN's with different access technologies. The ongoing work in IETF Mobile IP working group [MIP WG] is targeted towards such a mechanism[3]. Thus it is important to offer Mobile IP also to UMTS users and UMTS must be developed to support Mobile IP. Mobility within the UMTS CN could also be handled by Mobile IP. This would allow transparency to networks external to the UMTS PLMN. Potentially, this would allow cost savings for operators and a broadening of the market for manufacturers.

It is important to understand the different driving forces:

- Mobile IP as an overlay to the UMTS-GPRS would make it possible to offer easy roaming between different types of networks

- An integration of Mobile IP within the UMTS CN would additionally allow the operators to use standard IP technology to a larger extent and thus lower the cost for deployment and maintenance of networks.

Operators shall have the possibility to offer Mobile IP to end customers for R99. A flexible approach should be taken in order to extend the use of Mobile IP to handle mobility within the UMTS CN. UMTS standards should be aligned to when new Mobile IP functionality, that is needed for the different stages, will come out on the market. As not all operators will introduce Mobile IP at the same time, compatibility with GPRS based PLMN's is needed. Such a flexible, yet backward compatible, approach is outlined below.

The concept of surrogate registration [TEP] allows MS's without Mobile IP to benefit from Mobile IP infrastructure by letting the network perform the registration with the HA on behalf of the MS. However, this issue needs further investigation.

9.6.3 A staged introduction of Mobile IP in the UMTS CN

Three stages, which are discussed more in detail further down, have been identified. Briefly, these are:

1. Stage 1 represents a minimum configuration for an operator, who wishes to offer the mobile IP service. The current GPRS structure is kept and handles the mobility within the PLMN, while MIP allows user to roam between other systems, such as LAN's, and UMTS without loosing an ongoing session, e.g. TCP.

2.The SGSN and GGSN can be co-located without any alterations of the interfaces. However, to obtain more efficient routing, the MS could change GGSN/FA, i.e. PDP context and care-of address after an inter SGSN handover if it is not transferring data. MS's which are transferring data during the inter SGSN handover could perform the streamlining after the data transfer is completed, using the old GGSN as anchor during the completion of the data transfer.

3. The third stage is to let MIP handle also handover during ongoing data transfer. The Gn interface is here only needed

---

[3] Note that in this text, Mobile IP is used in a wide sense. It refers to [RFC2002] **and** ongoing and future work in the IETF Mobile IP Working Group [MIP WG].

for handling roaming customers without support for MIP.

9.6.3.1 Stage 1 – Offering Mobile IP service

Mobile IP has the benefit of being access system independent, which allows users to roam from one environment to another, between fixed and mobile, between public and private as well as between different public systems. Assuming a minimal impact on the GPRS standard and on networks whose operators do not wish to support MIP, leads to the following requirements:
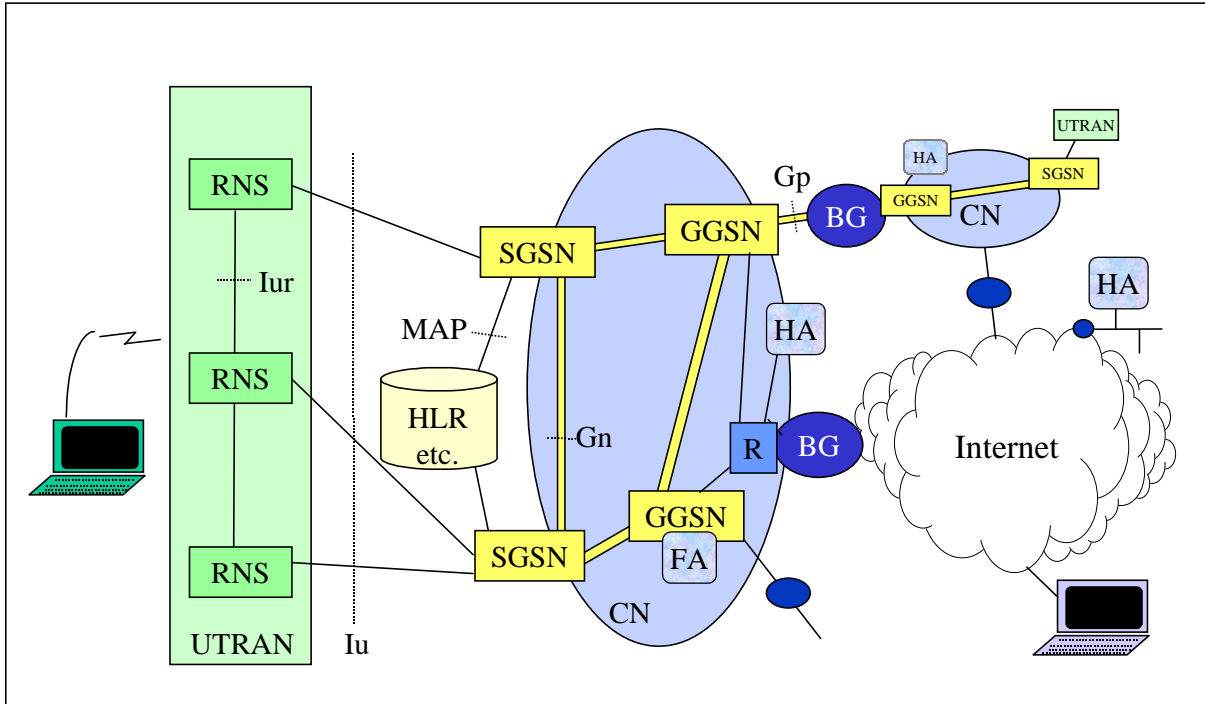
Figure 29. Core network architecture with GPRS MM in and between GPRS PLMN's and Mobile IP MM between different types of systems and optionally between GPRS PLMN's.

- The MS must be able to find a FA, preferably the nearest one. The underlying assumption is that FA's are located at GGSN's and that not all GGSN's may have FA's. One FA in a PLMN is sufficient for offering MIP service, however for capacity and efficiency reasons, more than one may be desired. This means that the MS must request a PDP context to be set up with a GGSN that offers FA functionality.

- While setting up the PDP context, the MS must be informed about network parameters of the FA, e.g. care-of address.

- Furthermore, the interaction between the GGSN and the FA needs to be studied more in detail. With the assumption that FA care-of addresses are used, the FA needs to detunnel incoming packets and, together with the GGSN, map the home address of the MS to a PDP context.

    Roaming can be handled either via the Gp interface or via Mobile IP. This is described in the section on roaming further down. It is assumed that the MS keeps the same care-of address as long as the PDP context is activated.

    A typical network is shown in Figure 29. The detailed solutions of this stage are to be worked out in [MIP-SMG4].

9.6 3.2 Stage 2 – Intermediate GPRS-Mobile IP system

One way to implement a GPRS backbone is to co-locate the SGSN and GGSN, as depicted in Figure 30 . This might be favorable for operators with a strong interest in utilizing standard IP (IETF) networks as far as possible and does not require any changes in the current GPRS protocol architecture.

(

In stage 1, the assumption was that the MS stays with the same care-of address, during a session, i.e. as long as a PDP context is activated. A very mobile MS, might perform several inter SGSN HO's during a long session which may cause inefficient routing. As an initial improvement, a streamlining procedure, with a temporary anchoring point in the GGSN, could be introduced:

If the MS is not transferring data while moving from one SGSN to another, a new PDP context could be setup between the new SGSN and its associated GGSN at the handover. The MS will get a new care-of address. The procedure for informing the MS that it has arrived to a new network has to be defined.

If the MS is transferring data, e.g. being involved in a TCP session, the MS would move from the old SGSN to the new one while keeping the PDP Context in the old (anchor) GGSN for the duration of the data transfer. Once the data transfer is terminated, the PDP Context can be moved to the GGSN associated with the new SGSN and a new care-of address can be obtained.

The buffer and forward mechanism, which already exists between the SGSN's for preventing data loss at inter SGSN HO's, will, with this procedure, be reused as it is. This procedure also has some advantage regarding the handling of firewalls, which are assumed to be attached to the GGSN's. Today, there is no standard for changing firewall during e.g. a TCP session.

As in the previous stage, the GPRS interfaces (Gn and Gp) need to be deployed for roaming customers, since there might be networks which not yet supports Mobile IP. Roaming between PLMN's can be handled either with Mobile IP or with GPRS.
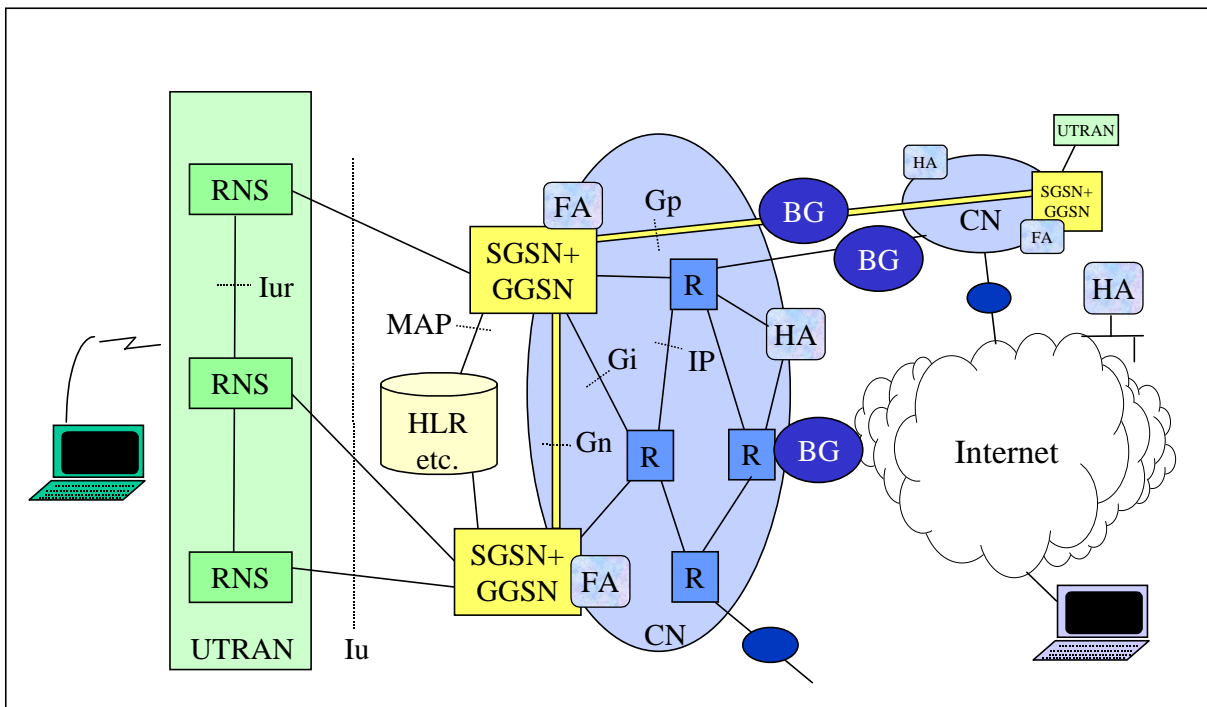
Figure 30. Core network architecture where GPRS MM handles active mobiles and Mobile IP streamlining at inter SGSN handover. The SGSN and GGSN are here co-located.

9.6.3.3 Stage 3 – Using Mobile IP for Intra System Mobility

The third and last stage is to let Mobile IP handle all intra system mobility, including all handovers between GGSN's or IGSN's. This is depicted in Figure 31, where the IGSN represents an integrated SGSN/GGSN. The Gn and Gp

interfaces may optionally be kept to handle roaming customers, whose terminals do not support MIP and the operator's own customers roaming to networks without MIP functionality. The main difference compared to the previous stage is that lossless handovers between IGSN's must be handled. This is the target architecture of an ongoing study in SMG12 [MIP-SMG12].
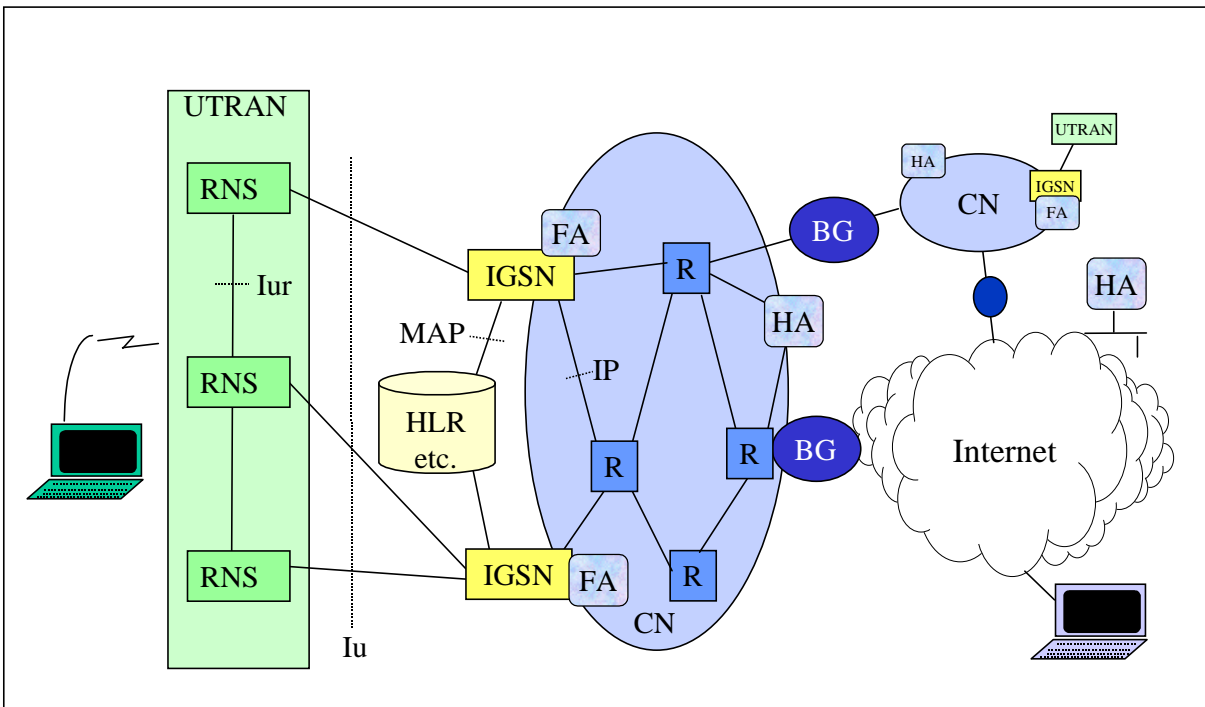
Figure 31. Core network architecture with Mobile IP MM within the CN and between different types of systems and between GPRS PLMN's.

9.6.4 Roaming

Depending on the capabilities of a visited network, two roaming schemes can be identified; GPRS roaming and MIP roaming. With GPRS roaming, we mean roaming via the Gp interface and the use of a GGSN in the home network, which is necessary when the visited network does not offer any FA's. In those cases where the visited network offers a FA, either a GGSN/FA in the visited or in the home network can be utilized. Networks, which use Mobile IP for all its own customers can provide GPRS roaming to visiting users by deploying the Gn and Gp interfaces.

9.6 5 Mobile IP and UMTS terminals

The mobile equipment needs to be enhanced with MIP software. For compatibility with other systems, it is of great importance that standard IETF Mobile IP and not a special UMTS version is used. Although it should be kept to a minimum, any interaction between the IP layer and the "UMTS layer" needs to be identified and defined. To avoid future updates of the mobile equipment, it should be considered to include the needed UMTS specific functionality of all three stages in the MS at once.

9.6.6 Surrogate Registrations

The concept of surrogate registration has a potential use in supporting non Mobile IP aware terminals using a Mobile IP based infrastructure. Instead of the MS performing registration with the Home Agent according to [RFC 2002], the FA could surrogate the mobile node in performing Mobile IP registrations with the Home Agent. One solution is proposed in [TEP] (Tunnel Establishment Protocol). However, surrogate registration may cause IP level authentication to be

dependent on UMTS authentication and hence increase the dependence of Mobile IP on the access technology. Further study is required on this topic.

9.7 Structure of air interface layer 3

- Connection Management

- Session Management

- Starting point is relevant parts of GSM 04-series, e.g. GSM 04.08

9.8 Iu reference point

9.8.1 General

As a first step, UMTS will be based on the GSM/GPRS network, i.e. one circuit switched and one packet oriented domain. Due to the differences of the domains, the Iu reference point will be realised by two Iu instances, one for each domain. This enables each domain to develop according to their specific characteristics. At the same time, an aligned view of the Iu reference point should be achieved where this is deemed suitable

9.8.2 Control structure for the Iu reference point.

- A multi-vendor interface shall be defined at the Iu reference point (Iu interface). The interface embodies a protocol suite allowing different protocol stacks towards the PSTN/ISDN domain and the IP domain.

- Over the Iu interface, user information to one UE is carried in one or several logical user flows, controlled by a signaling protocol (RANAP). Additionally some control elements (potentially relevant for only one domain) may be carried inband in the user flows.

- A common syntax for RANAP messages for both the IP and the PSTN/ISDN domain is the target as long as the functionality of either domain is not compromised.

- A guideline for defining the control procedures over the Iu reference point is to reuse, to the extent possible, control procedures defined in BSSMAP and BSSGP/GTP. The use of BSSMAP and BSSGP/GTP as the base when defining the control procedures over Iu does not preclude new control procedures to be introduced over Iu reference point.

- For each domain the protocol stack used by RANAP may be based on one of SS7, TCP/IP or a combination (e.g. SCCP on TCP/IP or UDP/IP). The protocol stack used by RANAP may be different for the PSTN/ISDN domain and the IP domain.

- The protocol stack used by the user data transport over Iu may be different from the protocol stack used by RANAP. Furthermore the user plane protocol stack may be different for the two domains.

9.8.3 Iu reference point - User plane towards IP domain

- The standard shall support that the user data flows transported over the Iu reference point to/from the 'IP domain' shall be multiplexed on top of common layer 2 resources.

- One or several AAL5/ATM Permanent VCs may be used as the common layer 2 resources between the UTRAN and the 'IP domain' of the CN. The reason for usage of several permanent AAL5/ATM VCs may e.g. be for load sharing and redundancy. It is also possible to use one switched VC per user flow (PDP context or radio access bearer).

9.8.4 Proposals for the User Plane for the IP Domain

The various proposals for the user plane for the IP domain at the Iu reference point can be classified in three broad categories.

Editors Note: Finally, a single protocol stack for the user plane for the IP domain will be specified. Currently, the following proposals are being evaluated.

Proposal 1: The proposed protocol stack is shown in Figure 1. This proposal is very similar to the user plane protocol stack in GPRS.
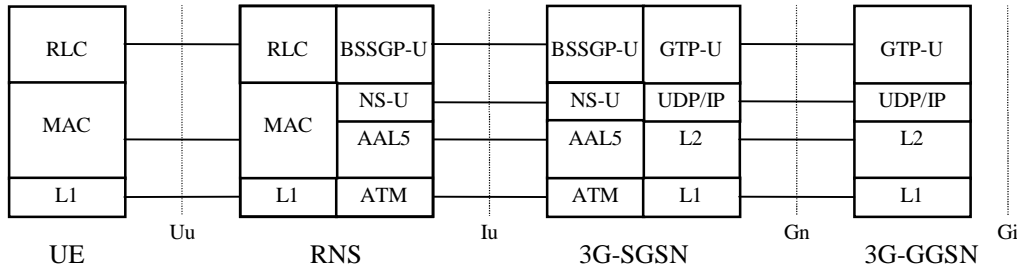
Note: Protocol layers above RLC and BSSGP-U are outside the scope of this contribution and FFS

Figure 32: User Plane Protocol Architecture for Proposal 1

Proposal 2: The proposed protocol stack is shown in Figure 2. In this proposal, a tunneling protocol is used between the SGSN and the UTRAN. Further, it is proposed that the tunneling protocol used is an evolution of the GTP protocol used in GPRS.
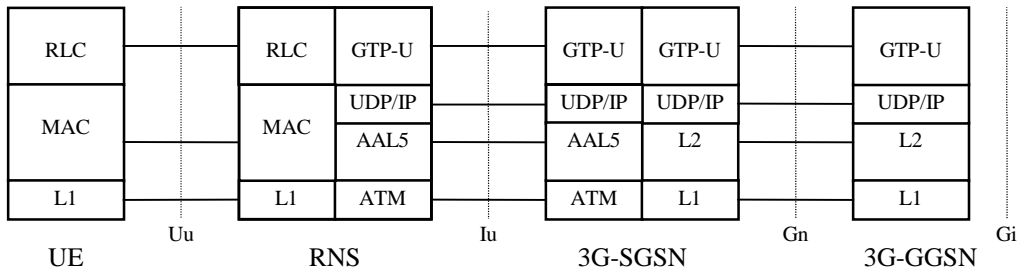
Note: Protocol layers above RLC and GTP-U are outside the scope of this contribution and FFS

Figure 33: User Plane Protocol Architecture for Proposal 2

Proposal 3: The proposed protocol stack is shown in Figure 3 (from DTR 23.20). In this proposal, a tunneling protocol is once again used at the Iu reference point. However, in this proposal, the SGSN does not perform any user plane functions at Layer 3.

(
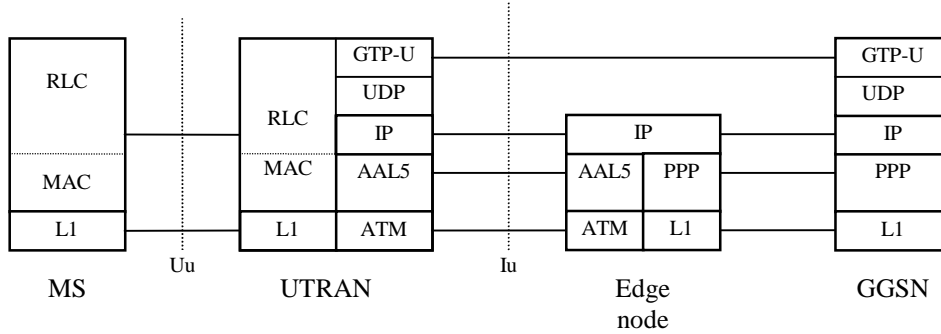
Figure 34: User Plane Protocol Architecture for Proposal 3

9.9 Dualmode operation (GSM/UMTS)

9.9.1 Will dualmode terminals also support GPRS?

9.9.1.1 Handovers between GSM/GPRS class A and UMTS terminals

In the following some problems and suggestions to solve the problems are made concerning the case where UMTS must support handovers from GSM to UMTS and/or UMTS to GSM for mobile stations with CS and PS service capability (GPRS class A).

9.9.1.2 Handover from GSM to UMTS

This type of handover could be needed, e.g., due to traffic reasons in a congested GSM network. In GSM the control for CS connection remains in the MSC from which the call was originated. This is called anchoring. Figure 35 illustrates the situation before the HO into UMTS (i.e., to UMTS UTRAN).
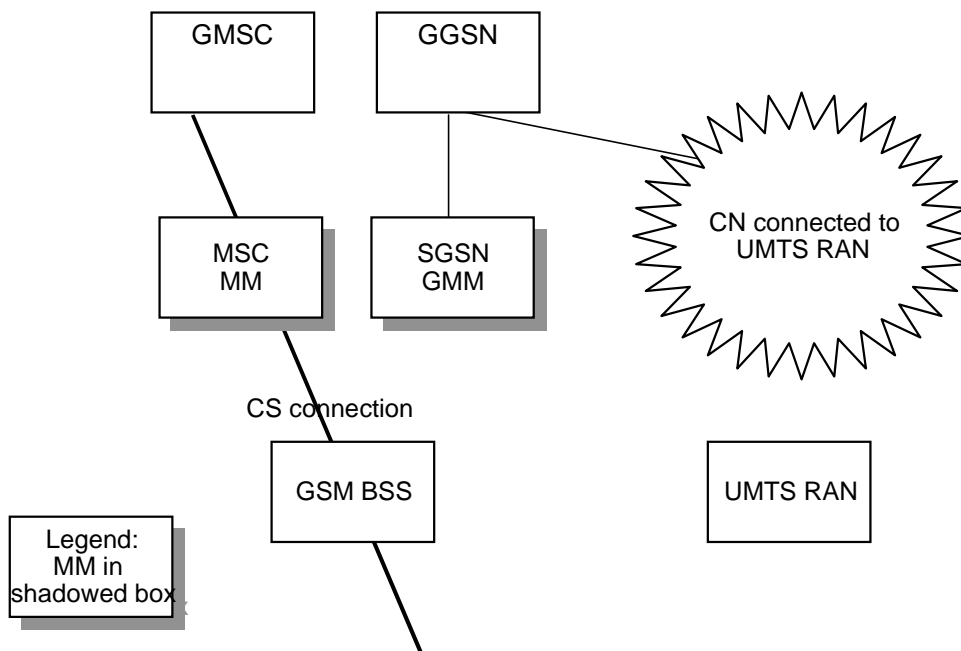
Figure 35. Before HO to UMTS from GSM. The PS services are provided from SGSN in GSM.

In order to have access to PS services after the HO, the MS has to perform the necessary update, obviously. The reason for this is that there are no means to change SGSN in GSM without doing so. However, as there is an active connection from GSM MSC, no updating can be done for CS services (i.e., to MSC connected to UMTS UTRAN) until the call has ended, i.e., the control and MM for CS remains in GSM. As a result, only the PS MM can be activated in UMTS and thus the MM is split into two due to the HO.
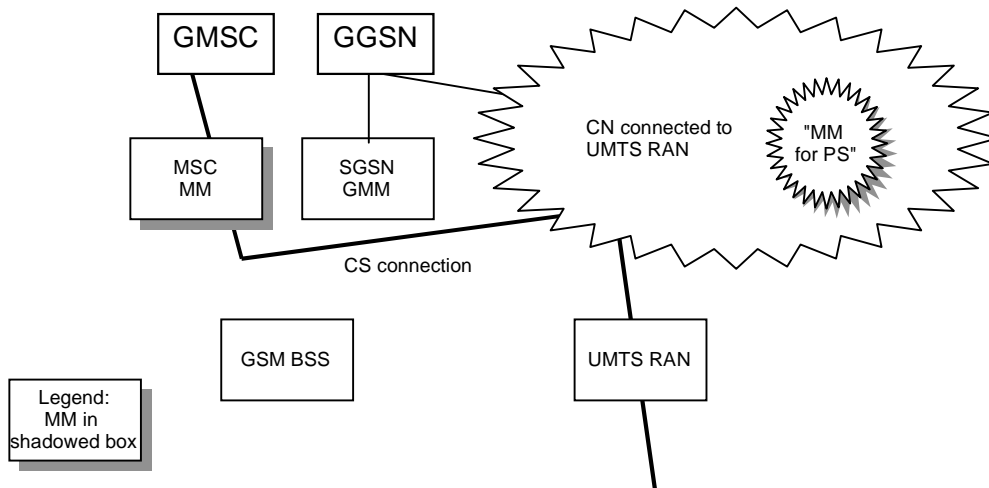
Figure 36 After HO to UMTS from GSM.

The PS services can only be accessed from UMTS CN. To avoid severe limitation on accessing the PS service during the length of the CS connection, "MM for PS" must be setup into UMTS CN. To support that, the MM in UMTS CN has to be able to be split into two like MM in GSM. Moreover, to support PS access the UTRAN needs to perform co-ordination similar to the one required for the core network architecture with two edge nodes (e.g. scenario 2).

9.9.1.3 Handover from UMTS to GSM

Figure 37 illustrates the situation before the HO; anchoring is assumed in UMTS CN. This type of handover could be needed, e.g., due to limited coverage of UMTS.
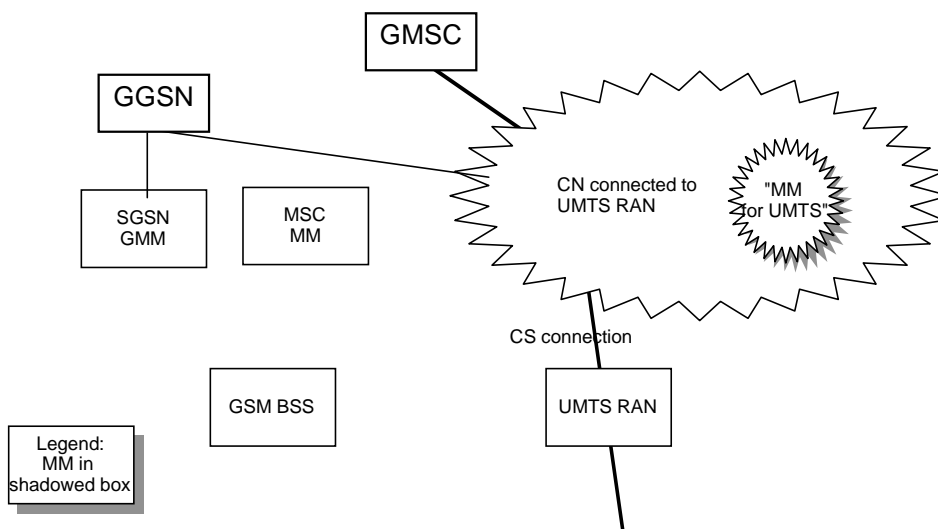
Figure 37 Before HO from UMTS to GSM.

This type of handovers are seen as important especially in the first stages of UMTS due to limited coverage. Without these, the end user perception may be seriously affected.

Again, to have access to the PS services after the HO, an appropriate update is needed and also no updating can be done for CS. As a result, MM instance only for PS can now be activated in GSM as long as the call lasts and as a result, the MM in UMTS is split into two due to the HO..
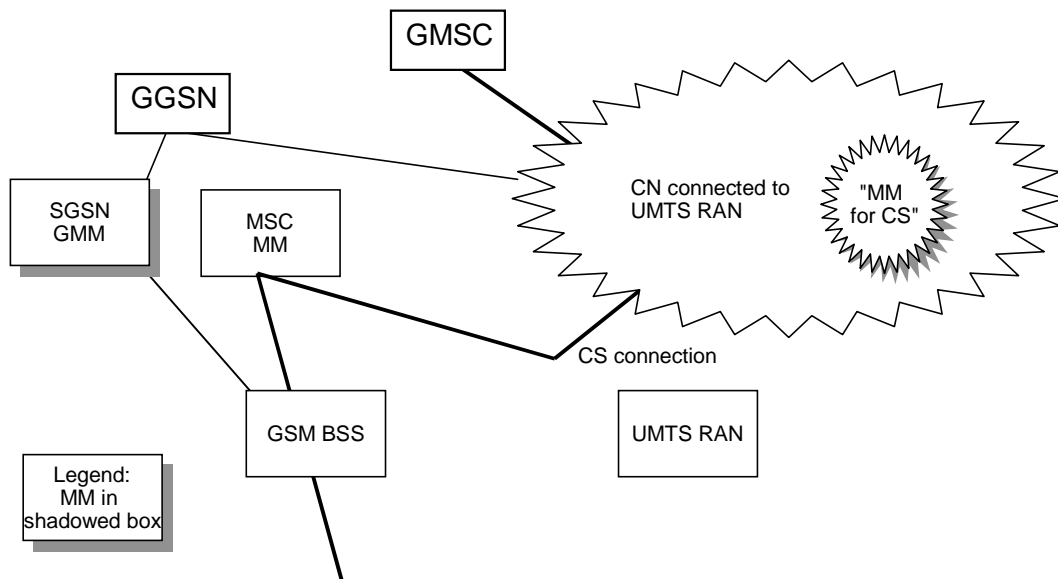
Figure 38 After HO from UMTS to GSM.

To have access for PS service in GSM, the "PS part of MM in UMTS" has to be transferred to GSM.

9.9.1.4 Suggestions

From the discussion above one can suggest that to support handovers between UMTS and GSM for class A type of mobiles:

1. UMTS MM must support some distinction between CS and PS services in the registration related procedures. An example is a dedicated update/cancel only to PS services in UMTS. This is likely to affect to the states of UMTS MM sublayer in MS and CN (independent of the selected MM solution)

2. The MS has to be capable of handling the GSM – UMTS dualism

3. The UTRAN has to support the operation. Required functions bear resemblance to the architecture where the core network has two edge nodes (MSC, SGSN).

Some of these problems may be alleviated if the UMTS core network node provides also GSM functionality (A and Gb) and there is no need to change the UMTS core network node during the handover. This is for further study.

Requirements due to handover for dualmode "UMTS class A" – GPRS class B terminal are ffs.

•   Handovers between GSM and UMTS for N-ISDN and packet oriented services (e.g. IP)

•   Idle mode operation of dual mode terminals (e.g. cells in same or different location areas)

9.10 Anchor concept

UMTS Mobility Management (UMM) for release 99 shall use packet anchoring at the GGSN, providing this mmets the QoS requirements, including those for real time services.

Disassociation of SRNS relocation and PS session transfer should be evaluated for release 99

9.10.1 Introduction to the concept of anchoring communications in GPRS

GPRS is being developed to include Quality of Service, this includes real time aspects. At present within GSM/GPRS the Core Network part of inter SGSN RA update procedure- is used to maintain communications within the network for a change of SGSN. GPRS will need development to support real time QoS requirements, the current mechanisms for changing the current SGSN (inter SGSN RA update) may also need developments to maintain the QoS requirements.

For UMTS the notion of Serving and Drift RNC provides a no loss of data at Hand-over inside a UTRAN as long as SRNS relocation (or a UMTS<=>GSM handover) is not performed (use of RLC between SRNC and UE in case of non-real time packet data, and use of soft handover in case of real time). The SRNC could be considered as an "anchor" point for the UTRAN. Therefore only the case of SGSN change induced by SRNS relocation has to be considered.

Within the UMTS CN two proposals have been made to satisfy the QoS requirements, the anchor SGSN concept and the non-anchor SGSN concept, both are illustrated in Figure 39 and are discussed in the following sections.

"Anchor SGSN" architecture   "Non-Anchor" SGSN architecture
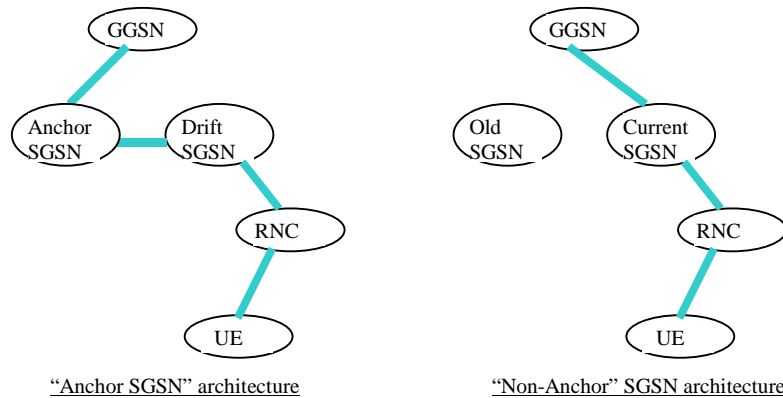
Figure 39: The "anchor SGSN" and the "non-anchor" SGSN architectures

9.10 2 The Anchor SGSN concept

This section proposes that the current technique for anchoring communications within the MSC is considered for application to the QoS based GPRS communications (i.e.between SGSNs). This technique is termed 'the Anchor SGSN concept' and is used to maintain the communications between the GGSN and the UE , with the SGSN(old) making a bearer link to the SGSN(new).

It should be noted that this concept may be applicable for UMTS as well as GPRS.

9.10.2.1 Requirements for the anchor SGSN

The requirements for the support of the SGSN anchor concept are discussed below

GPRS: With added QoS

To date GPRS has used a number of different QoS Criteria, however the GPRS (and UMTS) community have been looking at enhancing this to enable better support for real-time type features. The current Core Network GPRS inter SGSN RA update (SGSN change) relies upon the Old SGSN to suspend and buffer packet transmission, the new SGSN to interact with the GGSN/HLR to maintain the active session. The new SGSN then re-commences transmission and buffered packets (from the old SGSN) are passed to the mobile. The impact of this is potential breaks in transmission which would not satisfy Real-time/QoS requirements.

<u>The Core Network part of GPRS Cell re-selection: convergence with (inter MSC) handover?</u>

As GPRS adopts real time QoS, developments will be needed within the routing elements (GSN) to cater for the real-time nature of the packet communications. One upshot of this is within the QoS based environment the resource reservation paradigm moves towards a 'circuit switched' one (with resources 'reserved' for the QoS stream). With this in mind the support of the CN part of inter SGSN RA update in a QoS environment could become closer to a 'circuit switched' handover where the old and new paths are 'connected/bridged' during the actual handover. For UMTS the SRNS relocation within a QoS based GPRS network may require developments between SGSN to enable the paths to be connected at an inter SGSN level, rather than the current method of using the GGSN. Effectively the current GPRS inter SGSN RA update mechanism uses the GGSN as the anchor point.

To maintain the QoS requirements during a change of SGSN an SGSN based anchor point (similar to the current VMSC based anchor in GSM CS) could be applied. Following the successful SGSN change it may be possible to optimise the packet routing between the GGSN and new SGSN, this requires further study.

<u>SGSN based Anchor</u>

The adoption of an SGSN based anchor could ease some of the problems highlighted within ***UMM }*** where the MM becomes split between GSM/GPRS and UMTS when a handover between the two radio mechanisms occurs. At present the (GPRS) MM location follows the Packet Switched serving node (SGSN) as it moves within and between the networks, whereas the Circuit switched (CS) MM remains within the anchor MSC.   Further study should be made to see if the concept of anchoring of all services within the 'initial' network (network where communications were initiated) will ease the 'split MM' problem.

<u>MM enhancements</u>

Within the Circuit switched world the MM information is retained at the old MSC following an inter MSC handover and no location update is performed until the CS session (call) has been terminated. The adoption of a similar mechanism for Packet switched Services could ease the GSM-UMTS MM problem. If a CS session is in place the location update/routing area update would be constrained until the CS session is terminated (from the UTRAN perspective any PS packets would be routed over the common RRC session with no need for paging (in the now 'new' UTRAN RA/LA)).

9.10.2.2 Developments of GSM/GPRS for the SGSN based anchor

To enable the SGSN anchor concept to be supported the following developments will be needed to the contemporary GSM/GPRS network: these should be linked in to the overall UMTS developments:

  a) Support for GPRS/UMTS QoS during SGSN change (inter SGSN RA update). Modification of the contemporary inter SGSN RA update mechanisms to become similar (if not converged with) GSM inter MSC handover type mechanisms.

  b) Modification of the inter SGSN signalling mechanisms to support the transfer of related information directly between SGSNs (e.g. SRNC relocation parameters, cipher/security information).

  c) Development of mechanisms to support single MM (the relation of updates between the MSC/SGSN and HLR is for further study). The Gs interface may be enhanced to support this capability.

Developments in contemporary GSM/GPRS network are also required to enable the UMTS <=>GSM/GPRS interworking since the anchor point is currently the GGSN.

9.10.3 The non-Anchor SGSN concept

The non-anchor SGSN concept may be viewed as the method currently used within GPRS (R97) for a change of SGSN.

9.8.3.1   Current GPRS operation

Current GPRS does not use an anchor SGSN (the SGSN used at PDP context activation may not be used by the MS during the lifetime of this PDP context).

The main reason is that, while in Circuit Switched GSM the call duration is very short, the PDP context duration may be very long (and the user be very far away from the SGSN where it activated the PDP context).

Furthermore, current inter-2G-SGSN mechanisms do not support a 'drift' SGSN since, at the reception of a downstream PDU, it is not possible to page a MS in standby state through another SGSN (there is no support of this requirement for a (R97) SGSN).

Note: When in (UMTS) RRC Connected mode, the UTRAN caters for paging of the mobile when in PS CONNECTED.

9.8.3.2   Developments of GSM/GPRS for the non-SGSN based anchor

To satisfy the identified requirements for GSM/GPRS/UMTS R99, the following developments will be needed to the contemporary GSM/GPRS network:

   a) Support for GPRS/UMTS QoS mechanisms during inter SGSN RA update, this will involve continued linkage of the GGSN with the inter SGSN RA Update.

The current mechanisms for inter (2G)SGSN RA update are different to the mechanisms for inter MSC handover .

9.10.4   Analysis and comparison of the "anchor SGSN" and "non-anchor SGSN" concepts

The following aspects need to be considered when considering inter SGSN RA update concepts for GPRS/UMTS:

- Support of QoS requirements (e.g. transfer delay (for real time traffic), reliability (ability to handle correctly traffic requiring a high reliability), service interruption (for real time traffic)

- Relationship to mobility management

- Support of Class A/Simultaneous mode operation

- Resource usage within the network

- Developments needed within the standards

9.10.5 Support of QoS requirements

Transfer delay

Both the network and radio paths create delay within GPRS/UMTS communications. The non-anchor mechanism always crosses three GPRS nodes during communications (RNC, current SGSN, GGSN). The "anchor SGSN" architecture uses the same 3 nodes until an SGSN RA update occurs, then a new node (the drift SGSN) is added, with the communications 'anchored' at the initial SGSN. After an inter SGSN RA update in the SGSN anchor mechanism 4 nodes are used (RNC, drift SGSN, anchor SGSN, GGSN), the anchor SGSN relays user packets to the drift SGSN. The "non-anchor" architecture provides a lower network transfer delay and a lower jitter on this delay (less nodes implies less queuing). This is likely to be an issue for real time traffic such as VoIP. The impact of this needs to be assessed in relation to the delay over the radio path.

Reliability

Within the UTRAN the (acknowledged) RLC layer between UE and SRNC provides the reliability required by some (non real time – high reliability) traffic within the UTRAN. When there is a change of SRNC:

- - either the RNCs (if there is no LLC in the protocol definition of Iu) using packet transfer between old and new RNC

- • - or the CN (if there is an acknowledged LLC in the protocol definition of Iu) using packet transfer between old and new SGSN

can repeat the non acknowledged packets ensuring the reliability requested by the user.

The same reliability can be provided in both "anchor SGSN" / "non-anchor" SGSN architecture.

It should be noted that ARQ mechanisms (using acknowledged mode with repeats) do not guarantee to avoid break in transmission for real time applications (such as speech/VoIP).

Service interruption at SRNS relocation

With the anchor SGSN architecture service interruption may exist during the change over of path from old RNC to new RNC, mechanisms such as parallel paths could be used to prevent or minimise this. The anchor SGSN would acts as the anchor for multiple PDP contexts (potentially to different GGSN which could be located within different networks).

With the non-anchor mechanism service interruption may exist during the change over of path within the GGSN between the old SGSN and the new SGSN. The impacts (upon timing of inter SGSN RA update) of multiple PDP contexts (potentially to different GGSN which could be located within different networks) needs to be studied.

The impact on nodal buffering and path change requirements for both concepts

(e.g. between GGSN and old/new SGSN in non Anchor concept, and between anchor SGSN and drift SGSN in anchor concept), combined with the support of real time and non real time traffic needs to be assessed further.

Network resources used

As shown in Figure 39, the non-anchor SGSN architecture requires less nodes and transmission resources than the anchor SGSN architecture. However, the impacts upon the network resources in terms of signalling, buffering and processing load requirements need to be addressed.

Quality of service requirements

The optimum mechanism to satisfy the service requirements need to be considered, for example for a non real time, long duration packet session the anchor SGSN may not be optimum. Alternatively, for a real-time short duration packet session the non-anchor concept may not satisfy the QoS requirements at SRNS relocation. However, if SRNS relocation is not performed for real-time short duration packet session, there is no break in transmission at all (It is acceptable since the duration is short).

A mix of solutions may need to be considered in relation to the Quality of Service requirements of the packet session.

9.10.5.1 Support for Class A (GSM/GPRS) and UMTS Simultaneous Mode operation

Within GSM/GPRS the mechanisms used within the MS and the network to support Class B/C operation are different to those required for Class A. Simultaneous mode is required within UMTS (R99) which will place requirements to the GSM/.GPRS/UMTS R99 standards. The impacts on the network and MS usage and control of radio resource need to be addressed.

9.10.5.2 Mobility Management

For MM point of view, interworking with 2G-SGSN has to be considered. A non-anchor SGSN architecture makes it easy since the GGSN is the anchor point in both 2G-GPRS and UMTS networks. The concepts chosen for UMTS and GSM/GPRS for R99 need to be compatible.

In the case SGSN anchor concept is introduced in R99 GPRS, several issues have to be considered:

- • A new relaying protocol has to be introduced since BSSGP does not fulfil this requirement,

- • The MS behaviour has to be modified: in standby state, it has to initiate a cell update instead of a RA update,

- • The drift SGSN has to route the cell update to the anchor SGSN it does not already knows,

- When receiving a downstream PDU, the anchor SGSN has to page the MS under another SGSN. The use of P-TMSI may lead to conflicts since the same P-TMSI value may be already used for another MS.

- Interception and charging aspects, since the GGSN and the MS could be in different regions.

The current mechanism with UMM uses different mechanisms for PS and CS MM. The impacts of both mechanisms on GPRS MM/UMM and security/ciphering need to be addressed.

Within the anchor concept there are no RA updates as long as the MS has an active PDP context via anchor SGSN.

The non-anchor concept leads to RA updates with every change of SGSN; however, there is no RA update as long as the SRNS is not changed since the SRNS acts as an anchor point in the UTRAN.

The impacts of inter SGSN RA update for both anchor and non anchor solution in conjunction with location based services (such as SoLSA) needs to be addressed.

9.10.5.3   Comparison of developments needed within the standards for GSM/GPRS/UMTS R99

- R99 will include the support of QoS within GSM/GPRS and UMTS.

- Class A operation and UMTS simultaneous mode will be required for R99.

- The anchor SGSN concept would include the specification of drift SGSN and packet forwarding mechanisms.

- The non-anchor concept may need enhancement to satisfy the QoS concepts and will need development to ensure the interruption for inter SGSN RA update can be achieved within the QoS requirements.

- The changes and developments needed to GPRS R97 to satisfy these requirements as well as inter-working to pre R99 networks needs to be addressed.

9.11 Quality of service

- Application/End to end QoS

- QoS Segments (e.g. Radio, UTRAN, CN, Internet)

- QoS Mapping (between different segments/layers)

- Radio Access Bearers

- Resource management

- Interfaces/APIs between Application, TE, MT

- Charging of QoS aware applications

9.12 Others

9.12.1 Evolved GPRS/IP support for Multi-media service

The following developments are needed within IP/GPRS to support the expected multi-media requirements of UMTS (note this list is not exhaustive):

QoS for GPRS: To enable real-time 'streaming' developments.

Adoption of IP Telephony, H.323 and equivalent PSTN/Internet technologies: To support the control and interworking of multi-media and telephony applications with non-UMTS networks.

<u>Interrogation of the HLR with the Gateway functionality:</u> To enable terminated communications to be delivered to the mobile terminal. This can include the PIG and H323 functionality.

Figure Z illustrates a potential architecture which could be used to deliver telephony and multi-media features.
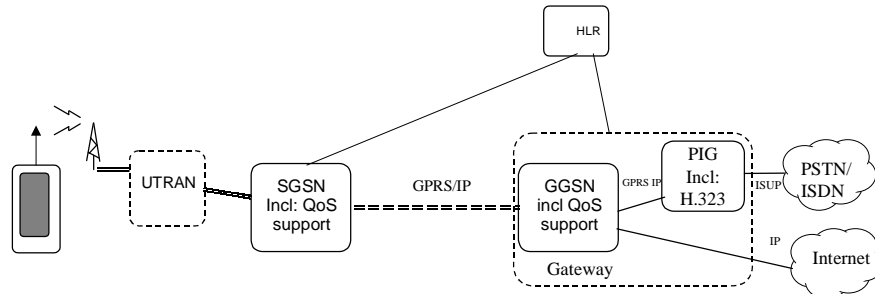
Figure 40: Evolved GPRS/IP support for Multi-media services

Telephony and multi-media requirements for UMTS may be supported via the evolved IP/GPRS network of Figure Z. This architecture does not need a separate non-IP based circuit switched (MSC) platform.

- Multimedia service control

- Phasing. What is for release -99, -00, etc. ?

- Network migration

- Handling and type of coded speech over Iu

- Location of ciphering functionality

- Link access control for user data (LAC-U)

- Data compression

- Allocation of resources of Iu

9.12.1 Separation of switching and control

<u>Proposed Architecture</u>

In this section the concept of a logically Separated Call Control (SCC) server is introduced. Currently CC is integrated with each of the MSCs in a network. Here it is suggested (and shown in figure 1) that a single CC function is implemented which is logically separated from the switch. The physical location of the SCC server is an implementation issue. Examples of implementation include:

- SCC integrated with IWU.

- SCC integrated with one or more switches. In this case a IWU may not be required between the SCC and the switch(s) with which it is implemented. IWUs would be used to connect to other switches.

- Standalone SCC.

Data required by the SCC could be held locally so as to reduce signalling load. This is likely to include data currently held in the HLR and VLR and a network resource database which allows the SCC to determine what network resources

(

are available and record the state of resources e.g. used, reserved or free. Figures 2 and 3 show the signalling flows in the network for mobile originated and mobile terminated calls respectively.

In figure 1 MM is shown as being integrated with the SCC. It could equally well be separated from the SCC.
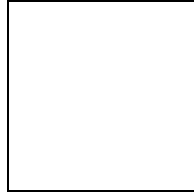
Figure 1 Network Architecture

Notes:

1. DBs represents all databases necessary for SCC operation, e.g. HLR, VLR, Network Resource database.

2. MAP (with some new operations) could be used here which would probably represent minimum change. Alternatively a more general protocol such as MGCP could be used which would represent more change but have the advantage that the switch would be made more generic.

3. ISUP (with some modified messages) could be used to communicate between the SCC and the transit switch of a neighbouring network.

4. This signalling is shown to pass through the transit switch as this is a likely (but not mandatory) route for it to take. The logical connection is between the SCC and the neighbour network.

5. MAP (with some new operations) could be used here which would probably represent minimum change. Alternatively a more general protocol could be used which would represent more change but have the advantage that the databases would become more generic. If an IN implementation is adoptred the SSF could form part of the SCC which could communicate with an SCF via MAP or INAP which in turn could communicate with the DB via DAP.

6. This interface could be the same vendor specific propriety interface that is implemented today internally to the MSC.

Mobile Originated Call
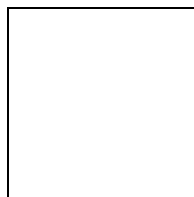
Figure 2. Signalling Flow for MO call.

Notes:

1. A modified SRI operation could be used by the SCC to request routing information from the databases. The response contains all the information required to route the call from the serving switch to the point of interconnect.

2. A modified IAM and ACM could be used to communicate between the SCC and the transit switch. Because the SCC serves multiple switches a switch ID (in addition to a route ID and circuit ID) is required.

3. EST (establish) and EST ACK could be a new MAP) or could be provided by a new protocol such as MGCP. Here EST is used to instruct the switch to establish the backward connection. EST ACK confirms that the required connection has been established. Note that the SCC executes the EST operation to all involved switches

(

simiItaneously. In the event of a handover the SCC would execute EST operations only to those switches involved in the handover. In the event that the neighbour network is not controlled by an SCC the transit switch is unlikely to be involved.

4. Here EST is used to instruct the switch to establish the forward connection.

Mobile Terminated Call

Figure 3. Signalling Flow for MT Call.

Notes:

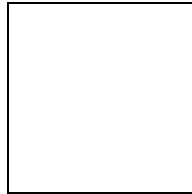1. A modified IAM and ACM could be used to communicate between the SCC and the transit switch. Because the SCC serves multiple switches a switch ID (in addition to a route ID and circuit ID) is required.

2. A modified SRI operation is used by the SCC to request routing information from the databases. The response contains all the information required to route the call from the serving switch to the point of interconnect.

3. For clarity MM is considered as part of SCC here.

4. EST (establish) and EST ACK could be a new MAP) or could be provided by a new protocol such as MGCP. Here EST is used to instruct the switch to establish the backward connection. EST ACK confirms that the required connection has been established.

5. Here EST is used to instruct the switch to establish the forward connection.

9.12.1.1 Benefits

The separation of switching and control functions offers the following benefits:

Architectural Flexibility: The separation of bearer from the control allows flexibility in locating the desired functions.(functions could either be centralised or distributed). For instance, the switching and call control functions performed by a circuit or packet switch can now be separated and located in physically distinct locations. The control functions (all or a part thereof) could be located in a "call control server", which can provide the information necessary to appropriately route the bearer. Further, this allows the use of platforms designed specifically for the task being performed to be used. Dedicated platforms will allow easier and faster software development and less work will be involved in rolling out new software versions.

Efficient Utilization of Network Resources Given that most of the traffic associated with a call is bearer traffic, optimal routing of bearers (facilitated by separating control from the bearer) allows efficient utilization of network resources. For instance, call control may be routed to a " Call Control server" for purposes of address resolution, billing, enabling of services, and others, but the bearer does not have to traverse through the call control server. Further, optimal routing can be maintained during mobility (the concept of an anchor MSC can be removed)since the bearers can be re-routed after a change in location. Optimising the routing in this way will have greater significance for UMTS calls which are likely to be high bandwidth and may also consist of multiple streams.

- Further optimal routing can be achieved in the case of call divert.

Bearer Flexibility and Robustness: The separation of bearer and control allows the communicating parties to negotiate the resources required (even possibly re-route the bearers) even after call setup has been completed. Bearers could be re-routed during a call due to a change in the performance required or to work around failure of network elements.

Future-Proof: The separation of bearers from control makes the protocols used more modular (than before). For instance, the same control protocols can be used over multiple transport technologies. Further, the same control protocol can be used for establishing multiple bearer types. This facilitates improvements in technologies being used with minimal impact.

9.12.1.2 Drawbacks

Separation of switching and control means defining the interfaces between the various control functions (such as cal control, mobility management, session control, etc) and the switching functions (i.e., switching matrix). For example in the case of a GSM MSC, this would mean defining an open interface between the MSC service switching functionality and the TDM switching matrix.

For packet data nodes, the separation might be more realistic as a client-server type of architecture is more natural in that domain. However, this is a deviation from the current GPRS and therefore may require additional standardization effort.

9.13. New Handover functionalities

The radio access network has to be capable of connecting to a variety of existing core networks. This leads to a requirement that the UTRAN will be allowed to connect with evolved forms of existing CNs. There will be the need to support new Handover functionalities between UMTS and 2G systems.

The support of multimedia services and the separation of Call Control and Connection Control (many connections: telephony, video, data could be associated with one single call and handed over separately), together with a micro or pico-cellular environment will cause increased complexity of Handovers compared with GSM.

Developments will be needed of the contemporary GSM/GPRS platforms to enable handover/cell reselection of communications between GSM/GPRS and UMTS. To enable this specific developments are needed for:

- Handover/cell reselection of communications which have inherent delay and error requirements (e.g. speech as for contemporary GSM circuit switched and speech/ video).
  (This may be viewed as an equivalent of GSM circuit switched handover).

- Handover/cell reselection of communications which may not have inherent delay requirements but do have error requirements (e.g. packet data communications such as IP/GPRS, file transfer, SMS).
  (This may be viewed as an equivalent of GPRS cell-reselection).

This also requires the ability to potentially 'negotiate' and modify communications parameters when handing over between GSM/GPRS and UMTS.

- It would be useful to provide new procedures in UMTS in order to make handover a totally Radio Resource Management procedure fulfilled as far as possible by the BSS without the intervention of the NSS part. The proposed interconnection of BSSs to allow for handover streamlining could be a step in this direction. (This may be difficult when performing hand-over between different environments, and a traditional GSM-like handover procedure is likely to be used in this case).

- It is likely that the network performance during handovers will be increased by restricting handover to the access network, leaving the core Network to deal with the Streamlining procedure without any real-time constraints. (In the case of a successful GSM inter-BSC handover, eight messages are exchanged real time on the A interface between the MSC and the two BSC; if Streamlining is used, this could be potentially reduced to two messages (Streamlining Request - Streamlining Acknowledge) with a significant saving in the signalling overhead.

As part of the overall QOS negotiation between user and network, mechanisms will be needed to enable parameters such as handover delay, jitter, packet/information loss/acceptable error etc to be applied as part of the communications path requirements utilised during the communications 'session'.

A number of options are available to support handover within the UMTS Core Network; real time support within the core network, real time handover within the UTRAN with subsequent 'streamlining'. Irrespective of the final mechanism developed within the UMTS Core Network for UMTS handover, functional developments are needed within the Core Networks (both GSM/GPRS and UMTS) to support handover between UMTS Core Networks and evolved GSM/GPRS core networks.

(

9.14 Reduction of UMTS signalling

9.14.1 Super-Charger

The signalling load associated with subscriber roaming can be high when either the MSC/VLR areas are small or the subscriber travels significantly. The Super-Charger concept aims to optimise signalling associated with subscriber data management by retaining subscription data in previously visited VLRs, where possible.

The benefits of the Super-Charger concept are:

- Reduction of signalling traffic for subscribers located in the home PLMN,

- Reduction of signalling traffic between the visited PLMN and the home PLMN,

- No new network nodes are required,

- Applicable to a wide range of protocol used for the transfer of data.

7.8.2.1 Overview of the Super-Charger Concept

The concept of the Super-Charged network is described with examples from GSM mobility management. However, Super-Charger can be applied to other scenarios and protocols. This is a further study.

Super-Charger retains subscriber data stored in VLRs after the subscriber has moved to a location area served by a different VLR. The HLR performs the insertion of subscriber data to the VLR serving the location area to which the subscriber has roamed. The subscriber data stored at previously visited VLRs shall not be maintained while the subscriber is located in a location area serviced by a different VLR.

When the subscriber moves to a location area served by a VLR that has retained the subscriber's subscription data, the VLR shall indicate to the HLR whether subscriber data is required. If the VLR indicates that subscription data is not required but the user's subscription data has changed the HLR shall send the new subscription data to the VLR. Figure x shows an example message flow in a Super-Charged network.

To ensure data consistency for super-charged VLRs a sequence numbering method can be used. A sequence number is added to the subscriber data record. This sequence number is incremented whenever the subscriber data record is changed for any reason. The sequence number is sent to the VLR in ISD. For non-super-charged VLRs this can be ignored. For super-charged VLRs it is stored and returned to the HLR in subsequent UpdateLocation messages. The HLR can then compare this sequence number with the value currently stored in the HLR to determine if the cached data is still valid.

With the Super-Charger activated subscriber information is no longer deleted from the VLR database when a mobile station moves from the location area served by the VLR. This results in the continuous growth of the VLR database size. Consequently, a new VLR data management system is required so that the VLR can handle newly arrived mobile stations. Two options for subscriber data management systems are:

- subscriber data for subscribers that are not currently served by the VLR shall be deleted periodically using a VLR audit system and/or,

- subscriber data for subscribers that are not currently served by the VLR shall be deleted dynamically to make room for the newly arrived subscribers.
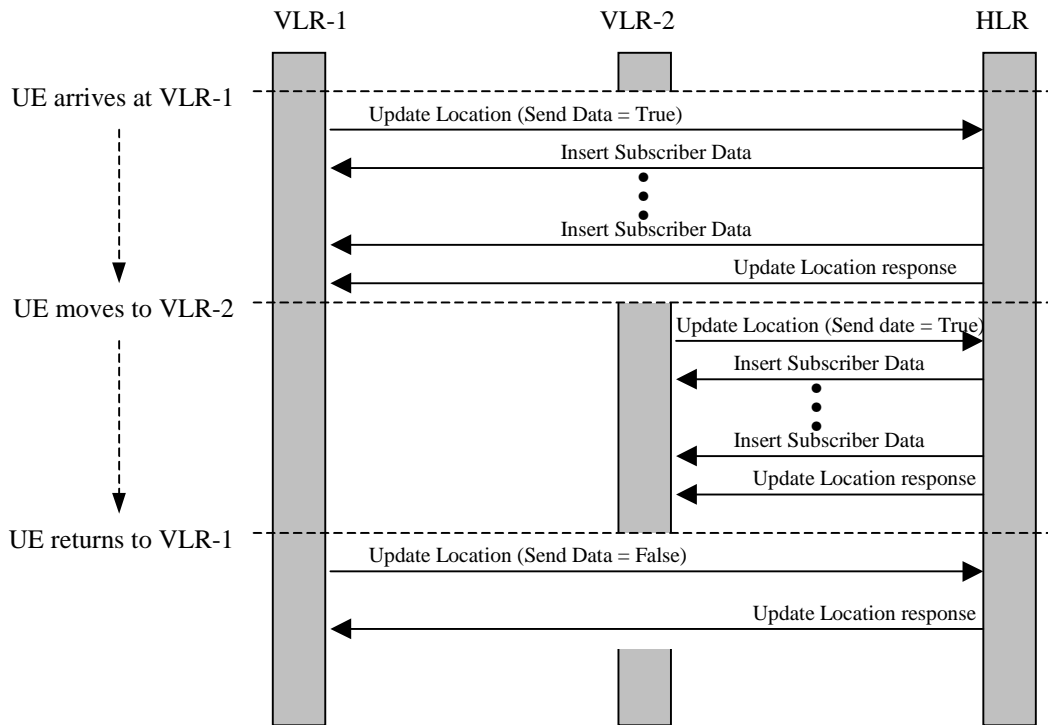
Figure 41: Example message flow in a Super-Charged network.

9.14.2 Turbo Charger

The signalling load associated with subscriber roaming can be high when either the location areas are small or the subscriber travels significantly. The Turbo-Charger concept aims to optimise signalling associated with subscriber data management by assigning one MSC/VLR to perform the Call Control and Mobility Management functions whle the subscriber remain attached or until signalling routes require further optimisation.

The benefits of the Turbo-Charger concept are:

- the substantial reduction in signalling traffic for subscribers located in the home PLMN,

- the substantial reduction in signalling traffic between the visited PLMN and the home PLMN,

- no new network nodes are required,

- applicable to a wide range of protocol used for the transfer of data.

The disadvantages of the turbo-charger concept are:

- Connections are required from the access network to be fully meshed to all MSCs in the turbo-charger area.

9.14.2.1 Overview of the Turbo-Charger Concept

A Turbo-Charged network constitutes a network architecture designed to reduce mobility management costs and provide automatic load-sharing between MSC/VLRs.

The architectural philosophy is to equally divide the subscribers between the available MSC/VLRs, irrespective of their location. In the context of GSM, this could beachieved by placing a routing function (eg evolved STP) between the BSC and the pool of MSC/VLRs. The purpose of the routing function is to route A-interface messages to the MSC/VLR that is serving the mobile station. The solution requires the MS to store a discriminant that can be used to identify the serving MSC/VLR and for routing to be applied on this discriminant on the connection between the MSC/VLR and access network.A TMSI partitioning scheme could beutilised. This scheme allocates a sub-set of the TMSI range to each MSC/VLR, Figure X. The A-interface messages are then routed to the right MSC based on the TMSI. This could be

done by a routing function external to the access network implying no access network modification (see figure x). If a TMSI partitioning scheme is used then new SIM cards are not required.

The temporary identity used for paging (TMSI) must be unique within all the MSCs in the turbocharger area. This implies that there must be a mechanism to ensure that this requirement is met for turbocharged MSCs (eg TMSI partitioning).

Two mechanism to provide load-sharing are envisaged, random load-sharing and dynamic load-sharing.

Random load-sharing requires the routing function to randomly assign a MSC/VLR to serve a particular mobile station when it first comes in to the network. Regardless of where the mobile is the same MSC/VLR will always serve it provided the mobile remains in the area served by all the turbocharged MSC/VLRs linked by the routing function.

In large metropolitan areas where subscribers are served by multiple MSC/VLRs, some MSC/VLRs may be very busy while others are not fully utilised. Dynamic load-sharing requires the implementation of an intelligent router. Since the routing function routes all A-interface traffic, it can participate in load-sharing and balancing based on the current loading of each MSC however linkage between MSC load and the routing algorithm would be required.

In the case of a Turbo-Charged network where the network is sub-divided into large regions, further optimisation can be achieved by adding the Super-Charger functionality.
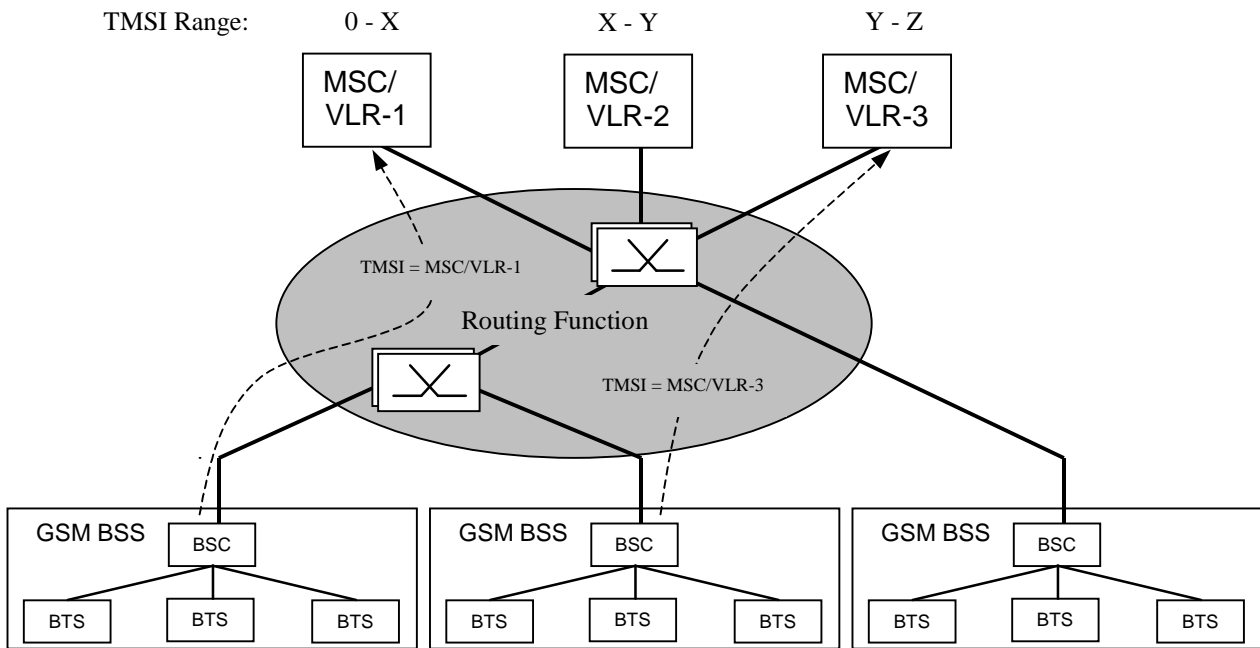
Figure 42: Example of GSM Turbo-Charger Network Architecture

In the context of UMTS, the routing function becomes a feature of the RNC, see **Error! Reference source not found.**.

(
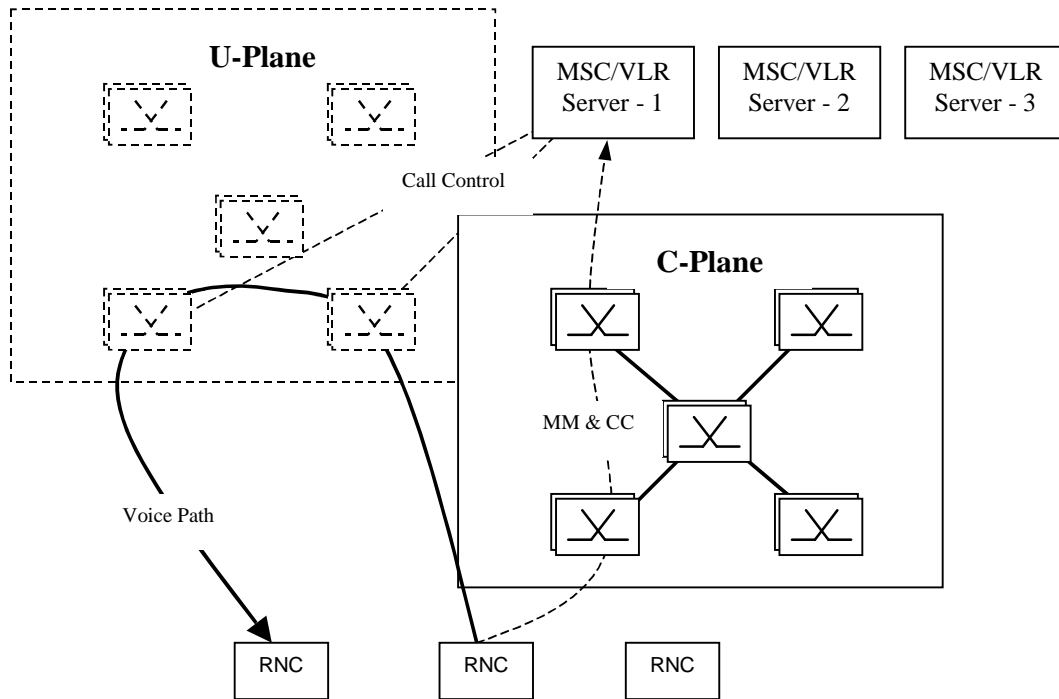
Figure 43: Example of UMTS Turbo-Charger Network Architecture

9.14.3 Relationship between GLR and TurboCharger

The GLR and TurboCharger are two independent schemes for reducing the amount of MAP traffic generated in UMTS networks.

• The GLR works by reducing traffic between PLMNs associated with Location Updates. This is achieved by "caching" the roaming subscriber's data in the visited network

• The TurboCharger works by eliminating the need to perform location updates. The same VLR can hold a subscriber's data for the duration of his attachment to the network.

A TurboCharged network requires that each MSC/VLR can physically connect to all RNCs. Therefore TurboCharging may be best suited to areas of the network characterised by dense geographic coverage. On the other hand, the GLR function is independent of the network density.

The network structure illustrated in **Error! Reference source not found.** shows that the GLR and a TurboCharged area within the same PLMN are independent. In fact, it shows benefits from using the two techniques in the same network. The Turbo-Charger reduces the location registration signals between the MSC/VLR and GLR:

• There is no new update location signal between MSC/VLR and GLR if roamer moves inside of the Region A.

• There is no new update location signal between GLR and HLR if roamer moves between regions.
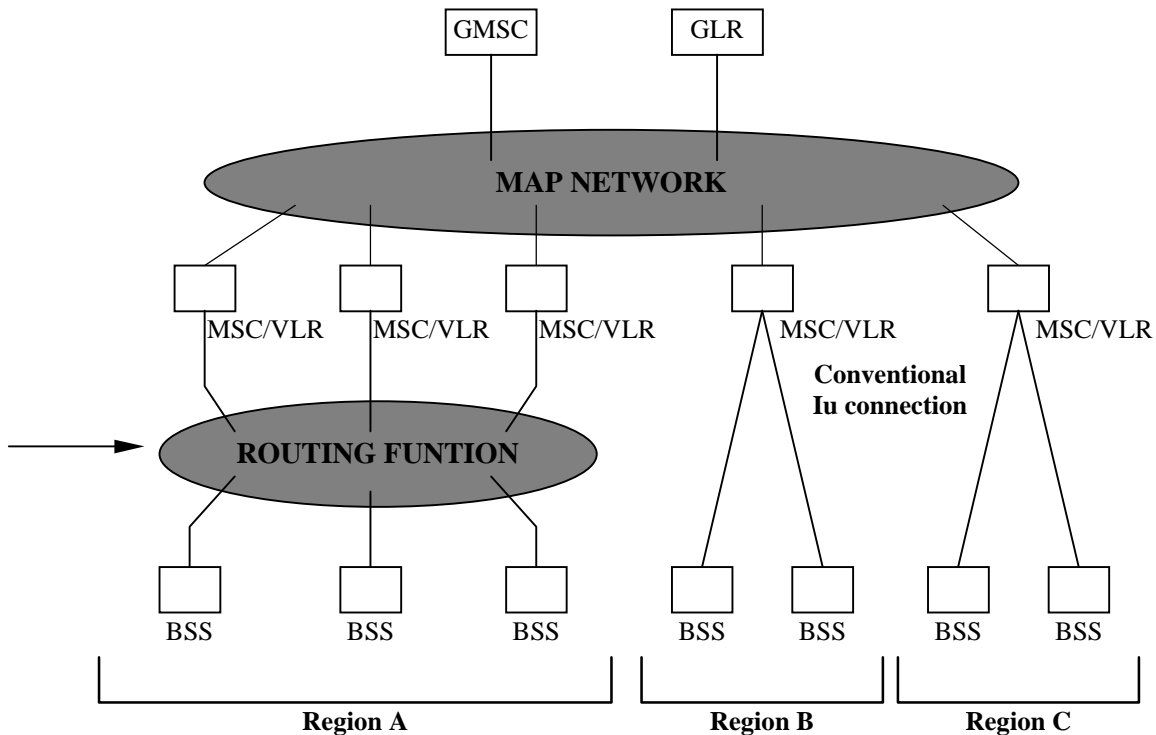
Figure 44.

9.15 Transcoder Control

In order to improve voice quality for mobile-to-mobile calls (MS-MS calls) in GSM Phase 2+ networks, Tandem Free Operation (TFO) using in-band signaling has been specified. The equivalent function in Japan's PDC (Personal Digital Cellular) network is known as Transcoder Bypass, which has been specified to make use of out-of-band signaling control (i.e. by the PDC-MAP protocol).

It is likely that UMTS terminals will support a wider range of codecs than is currently the case for GSM terminals. In the case of calls between UMTS terminals, codec negotiation will be needed to:

- match terminal capabilities during call establishment

- support supplementary services interactions such as with conference/Multi-party calling, ECT, CFNRy

- support changes in radio interface conditions.

This requires control of the transcoder unit in the UMTS Core Network during (and after) call establishment and handover. However, the inband signalling technique currently specified for GSM-TFO has limitations in this area. For example:

- **UMTS call setup;** the GSM-TFO mechanism is designed to support a limited set of codecs. Each time a new codec is introduced into UMTS the transcoder would need to be upgraded.

- **UMTS call in progress;** codec negotiation using the GSM-TFO mechanism would need complex in band signalling.

The different solutions to support the required functionality for transcoder control in UMTS need to be studied in detail. Signalling for codec negotiation and control may be achieved by:

- New control mechanisms between the mobile terminal and the network based transcoder (out of band and in-band solutions need to be studied).

- Revisions to ISUP signalling.

- Revisions to MAP signalling.

- Inband signalling mechanism developed for AMR

It is for further study what impact transcoder control has upon networks external to the PLMN.

9.16. Support of multimedia services

One of the most important requirements for UMTS is the capability of supporting multimedia services.

The following principles should guide and apply to the support of multimedia services in UMTS:

- Multimedia services in relation to UMTS should be standardized and handled according to emerging multimedia standards. SMG should not standardize multimedia services solely for UMTS networks. SMG should take advantage of existing and emerging main stream standards for multimedia, in reality defined outside of the UMTS.

- Multimedia applications according to such main stream standards should be *supported* (transported and handled) *efficiently* in the UMTS.

- Multimedia requirements on the UMTS should, as far as possible, explicitly be related to such multimedia application standards to be supported – rather than to generic statements or assumptions related to the architecture.

- The multimedia bearer capability requirements, incl. QoS, are expected to effect the core as well as the radio network.

Among others, two requirements for an efficient support for multimedia applications, which currently can not be achieved by GSM, are sufficient bandwidth allocation and flexibility of bearers.

- The bandwidth requirement relates to the transport technology used on (both the radio and network sides). In particular switching and transport capabilities within the network must be able to support, in an efficient and flexible way, air interface rates of at least up to 2 Mbit/s. It is unlikely that a 64 kbit/s based switching system will be able to do this in the most efficient manner.

- Separation of call control from connection and bearer control. This is an important requirement to satisfy the concept of Quality of Service for media components: a call/session may use various connections at any one particular instant (making use of one or several bearers). It should then be possible to add or remove bearers during such a call in order to cope with user needs or problems on the radio path. (Ref. ETS 22.01 Service Principles)

9.17. Support of services requiring variable bit rate

- If a number of applications use VBR data flows then packet transfer mode on the radio and network side has to be considered in order to make efficient use of resources.

- If packet transfer is allowed on the radio side, a finer degree of location management is/may be needed for radio resource optimisation (if only the LAI is used as in GSM, packets addressed to one single mobile terminal would need to be broadcasted over its entire Location Area; a new routing concept playing a similar role to the GPRS routing area is then needed).These additional Radio Resource/Mobility Management functions could be located in the Radio Access Domain, containing data strictly related to the access techniques that could be hidden from the serving network.

9.18 UMTS Simultaneous Mode.

Within GSM/GPRS Class A mobiles have been defined which support 'simultaneous operation of both GPRS and other GSM services'. UMTS is intended to enable users to access a variety of communications features including access to PSTN/ISDN services/features as well as IP capability. The UTRAN developments have a mechanism to support common 'pipe' over the radio interface (the RRC Connection). It is expected that multi-media and mixed media (PSTN/ISDN/IP communications) will play a large part of UMTS communications.

From this perspective it is essential for UMTS that from day 1 of network launch that mobile terminals can support both PSTN/ISDN services and features as well as IP simultaneously. Based upon this aspect 'Simultaneous mode' has been defined for UMTS communications. This definition can be applied to both network and mobile terminals.

Simultaneous mode is defined as the support of active parallel CS and PS communications.

The UE has simultaneous PS MM Connected and CS MM Connected states when in UE simultaneous mode.

Note: The support of 'Simultaneous mode' should not prevent the operation of mobile terminals in solely CS MM or PS MM connected mode. Simultaneous mode capable terminals should be supported in CS service and PS service only capable networks. Operators may wish to just use 3G_MSC and/or 3G_GSNs if required.

The impact of supporting 'Simultaneous mode' operation of the UE needs to be addressed within the UMTS System as a whole. In particular, the impacts upon the UE, radio, UTRAN and Core Network nodes need to be assessed.

10. Interoperability between GSM and UMTS

- Transparency [from a users perspective] of roaming and handover

- Re-use of existing subscription profiles

Note: This list is not exhaustive and is FFS.

This allows easier management and deployment of a new UMTS network.

UMTS is a system supporting handovers between GSM and UMTS in both directions. To support these handovers effectively, the following is required from a dual mode MS/UE supporting simultaneous ISDN/PSTN and packet service in GSM/UMTS:

Depending upon the solution adopted for GSM-UMTS handover, the MS/UE supporting simultaneous ISDN/PSTN and packet service may be requiredto perform appropriate update into CN depending on the activity of the UE once the handover between GSM and UMTS is completed. This update is needed to avoid any severe interruptions on the accessibility of packet services after the handover.

The nature of the update to be made after the handover in both direction, i.e., from GSM to UMTS and from UMTS to GSM, from MS/UE depends on the activity of the UE in the following way:

ISDN/PSTN connection: RA update only (if RA is changed)

Packet connection: LA and RA update (if RA and LA are changed)

Both ISDN/PSTN and packet connection: RA update only (if RA is changed)

If the RA, LA or both LA and RA are not changed the MS/UE behavior is for further study

10.1 Circuit Switched Handover and Roaming Principles

Introduction of a UMTS Core Network necessitates the inter-connection with legacy systems to allow inter-PLMN roaming and handover.

For ease of convergence with the existing networks and the introduction of dual mode handsets, roaming and handover to/from UMTS should be performed in the simplest manner that requires as little change as possible to the legacy networks and standards, i.e. inter-MSC handover functionality.

These principles provide - from a user perspective - transparency of handover and roaming. In addition, operators providing UMTS services should also allow access to legacy networks using existing subscriber profiles and network interfaces.

Illustrated in Figure 45 shows the introduction of a UMTS Core Network for UMTS phase 1 network configuration. Notice that it leaves the current GSM specifications mainly untouched whereupon the UMTS core network acts towards the GSM MSC like a GSM MSC by providing for example MAP/E for handover purposes. Further, it should be observed that GSM subscriptions belong to the HLR whilst UMTS subscriptions exist in the ~~UHLR~~HLR release 99..

Figure xx. Inter-Operability between GSM and UMTS

Figure 45 Inter-Operability between GSM and UMTS

Note: No physical implementation should be taken from the figure. As a further note, no interworking functions are shown to ease clarity, but however should not be precluded.

From Figure 45 it can be seen that the information exchanged over the Iu must provide the necessary parameters to enable the core networks to communicate via for example the MAP interface for handover purposes.

Also note that from the above diagram, existing interfaces are used towards the HLR to allow for subscription management based on today's principles using the already defined user profile, providing seamless roaming between the 2_{nd} generation system and UMTS.

The existing GSM handover procedures should be re-used to minimise the effects on existing GSM equipment (figure 1).

- The anchor concept in GSM for inter-MSC handover should be used for inter-system handover between UMTS and GSM.

- The signalling over the A-interface and over the MAP/E-interface should be the same as in GSM phase 2+ with possibly addition of some new or updated information elements in some messages.

- For the set up of the handover leg (user plane) standard ISUP/POTS should be used in line with the principles used in GSM.

- The control signalling over the Iu-interface at handover between UMTS and GSM should be based on the A-interface signalling at inter-MSC handover in GSM.

- The signalling over the Iu-interface at call set up to/from a dual mode UMTS/GSM mobile station, shall include GSM information elements needed for handover from UMTS to GSM.
  In the corresponding way the signalling over the A-interface at call set up to/from a dual mode UMTS/GSM mobile shall include UMTS elements needed for handover from GSM to UMTS.
  The data are needed to initiate the handover towards the new BSS/RNC.

- A target cell based on CGI is sent to the MSC from UTRAN at handover from UMTS to GSM. The CGI points out the target MSC and target BSC.
  The target "cell" identifier for UMTS at handover in the direction GSM to UMTS is for further study.

10.2 Packet Switched Handover and Roaming Principles

The introduction of a UMTS core Network as described in section 11.1 illustrates the requirement for inter-connection with the legacy GSM system to allow inter-PLMN roaming and handover.

Even though there is no current GPRS deployment, the operator may decide to deploy a GPRS network prior to the deployment of a UMTS network. Therefore, the introduction of a UMTS Core Network may require to be inter-connected to the legacy packet network.

As in the circuit switched case, roaming and handover to/from UMTS should be performed in the simplest manner that requires as little change as possible to the GPRS network and standards, i.e. inter-GSN handover functionality. In addition, access is provided to the GPRS network using the existing subscriber profiles and current network interfaces.

A similar figure to Figure 45 is illustrated in Figure 46. Notice that it also leaves the current GPRS specifications mainly untouched whereupon the UMTS core network acts towards the GSN like a GSN by providing for example Gn. Further, it should be observed that GPRS subscriptions belong to the HLR whilst UMTS subscriptions exist in the ~~UHLR~~HLR release 99.
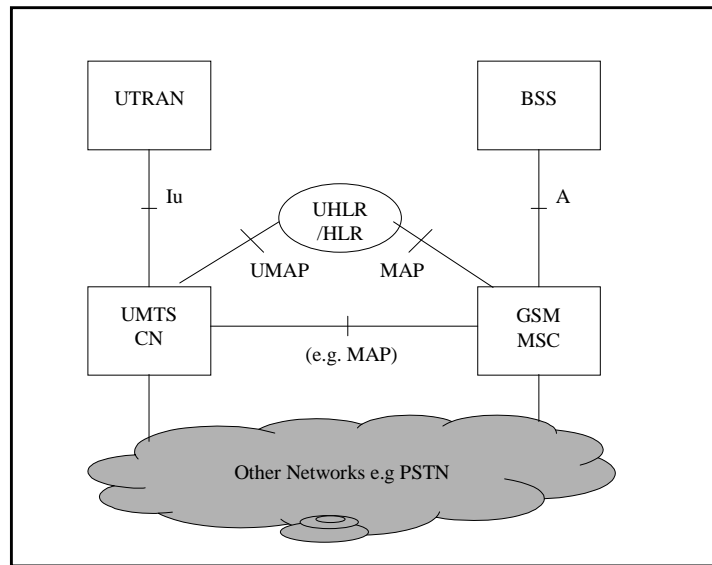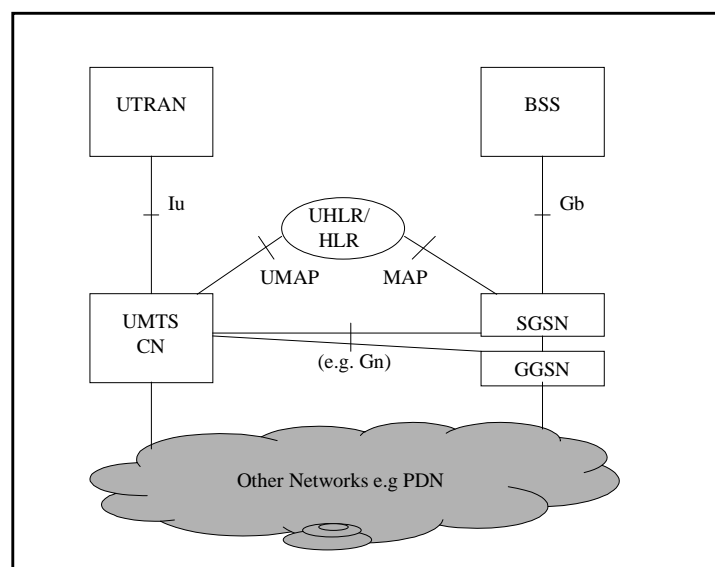

Figure xx. Inter-Operability between GSNs and UMTS

Figure 46 Inter-Operability between GSNs and UMTS

Note: No physical implementation should be taken from Figure 46. As a further note, no interworking functions are shown to ease clarity, but however should not be precluded.

From Figure 46 it can be seen that to provide inter-working between legacy packet switched and UMTS packet switched services, the information exchanged over the Iu must provide the necessary parameters to enable the core networks to communicate via for example the Gn interface for handover purposes.

Also note that from the above diagram, the same principles are used as in the circuit switched services to provide seamless roaming.

10.2.1 Implications

- The active PDP context resides in the same GGSN even after a handover between GSM and UMTS (both directions). This corresponds in principle to the anchor concept on the circuit switched side, but note that whereas packet sessions are long lived, the anchor MSC remains only for the duration of a CS call (typically much shorter than a packet session).

- Assuming an internal structure in UMTS CN that contains logical GGSN and SGSN nodes, the signalling over the inter-system GGSN-SGSN interface should be a joint evolution of Gn for the GSM system and UMTS. I.e., when Gn evolves in the sequence of GSM releases, Gn should include any new or updated information necessary for interoperation.

- The corresponding SGSN-SGSN inter-system interface (also Gn) should also be evolved together. However, in this case the changes relative to the current GPRS release may possibly be more profound.

11 Network Migration And Evolution

The installed base of GSM networks will be very comprehensive at the time of the UMTS roll out. These GSM networks will co-operate very closely with and in many cases be partly integrated into the overall UMTS network. Thus network migration and evolution is a very fundamental aspect to consider when standardising UMTS.

11.1 Network Migration Scenarios

A number of principally different network migration scenarios can be envisioned, e.g.:

- GSM to GSM release 99 (GSM operator with no UMTS licence and no UMTS roaming/handover agreements).

- GSM to GSM release 99 with support for dual mode 'UMTS visitors' (GSM operator with no UMTS licence but with UMTS roaming/handover agreements).

- GSM to GSM/UMTS (GSM operator with a UMTS licence).

- UMTS only PLMN (new UMTS operator with GSM roaming/handover agreements). This scenario is more a matter of network 'compatibility' rather than network migration.

A basic assumption is that the provision of UMTS services in most cases will start, from a radio coverage point of view, within 'islands in a sea of GSM BSS'.

11.2 network migration and evolution requirements

1) The UMTS standard shall consider all aspects of network migration and shall describe the migration process from GSM release 98 to UMTS/GSM release 99, including the aspect of partly updated networks and its consequences on end-user services etc.

2) While fulfilling the SMG1 requirements the UMTS standard shall aim at minimising the impact on the existing GSM networks delivering only GSM. It is recognised that GSM/GPRS standards will need developments for UMTS however these should not adversely impact the networks that offer GSM only.

3) It shall be possible to perform the network migration process of a PLMN independently of co-operating PLMNs.

4) It shall be possible to gradually migrate a PLMN, i.e. the UMTS standard shall allow network elements compliant with different GSM releases to co-exist within a PLMN.

5) The impact on end-user service level for partly updated PLMN(s) is FFS.

6) Internetworking within a PLMN as well as between different PLMNs shall allow operators to utilise current backbone networks (dedicated for GSM traffic only or carrying non-mobile traffic as well according to non-PLMN specific standards).

7) A GSM/UMTS mobile terminal shall be reachable from an external network (PSTN/ISDN, IP, X.25) regardless of the mobile terminal being served by BSS or UTRAN.

8) A terminal in an external network, as well as the external networks themselves, shall not need to know if the GSM/UMTS mobile terminal is served by BSS or UTRAN.

9) The user equipment shall not need to change the E.164 or IP address at handover between UTRAN and BSS.

12 Protocol Architecture

12.1 I_U Signaling Bearer Requirements for IP Domain

12.1.1   Connectionless and Connection Oriented Services

Connection-oriented and connection-less I_U Signaling Bearers are required.

12.1.2   Dynamic Bandwidth Allocation

The I_U Signaling Bearer shall support rapid and flexible allocation and de-allocation of I_U transport resources.

12.1.3   Reliable Transfer

The I_U Signaling Bearer shall provide reliable delivery of signaling data.

12.1.4   Flow Control

The I_U Signaling Bearer shall provide throttling mechanisms to adapt to intermittent congestion in the UTRAN or Core Network.

12.1.5   Redundancy and Load Sharing

To handle detected failures and signaling data congestion, the I_U Signaling Bearer shall be capable of dynamically routing over alternate routes that minimize delay. If the delay metrics over alternative routes are identical, the I_U Signaling Bearer shall be capable of spreading traffic over the identical paths, thus performing load sharing.

12.1.6   Large Pdu Size

To support large transactions, it is important for the I_U Signaling Bearer to provide a Signaling Data Unit size, large enough to allow for all signaling messages to be transferred without fragmentation.

12.1.7 Signaling Bearer Management

To support supervision of I_U Signaling Bearers, mechanisms for managing I_U Signaling Bearers shall be used to provide status information to the RANAP for individual UE(s). The signaling bearer shall also maintain a consistent UE Activation State in the access and the core network.

12.1.8   Transport Media Independence

The I_U Signaling Bearer shall be independent of the underlying transport media (e.g. ATM).

12.2

History

Document history		
Date	**Status**	**Comment**
21 May 1997	Version 0.0.1	Creation of Document with output from SMG 3 SA Meeting (Sophia Antipolis, May 97)
07 July 1997	Version 0.0.2	SMG 3 SA meeting output version (Sophia Antipolis, 04.07.97)
25 Sept 1997	Version 0.0.3	SMG3 SA meeting output version (Paris August 97) Application of new template according to ETSI rules.
06 Nov 1997	Version 0.1.0	SMG3 SA meeting output version (Milan Oct 97)
21 Nov 1997	Version 0.2.0	SMG3 SA Meeting output version (Kista, Nov 97) Inclusion of Tdocs 97s380,97s385 and 97s394
09 Mar 1998	Version 0.3.0	SMG3 SA Meeting output version (Malmo Jan 98) Inclusion of Tdoc 98s080 and deletion of 2nd Bullet point of section 7.4 as agreed in the minutes re: 98s075
12 Mar 1998	Version 0.3.1	Corrected V. 0.3.0
15 April 1998	Version 0.4.0	SMG3 SA Meeting output version (Bad Aibling March 98) Inclusion of Tdoc 98S133
15 May 1998	Version 0.5.0	SMG3 SA Meeting output version (Lisbon ,May 98) Inclusion of Tdoc 98S311 and Tdoc 98S314
18 May 1998	Version 0.5.5	Preliminary restructured version without new scenarios
26 May 1998	Version 0.5.6	New Scenarios Included
29 July 1998	Version 0.6.0	SMG12 Meeting Output Version (Chicago, June 1998 Inclusion of Tdoc 98S353, 98S325, 98S334 modified,98S368 modified, 98S354, 98S427 modified, 98S361 modified, 98S356, 98S359. ('Modified' implies version approved via email exploder) - Update of all figure numbers, with minor adjustments in text to take this into account.

(

25th August 1998	Version 0.7.0	SMG12 Meeting output version (Sophia Antipolis, August 1998. Inclusion of new scenarios Tdocs 98S504, 98S509, 98S585, 98S606, 98S607, 98S645, 98S648, 98S649. Removal of phasing headers to the scenario chapters. (Change bars not used on chapter numbering to ease reading) Inclusion of Tdoc658 in section 8.0 (See minutes) Inclusion of Tdocs 503, 511, 531(part) and 584 New chapter 10 as proposed on Tdoc630 Inclusion of details on VHE - Tdoc 513,540, 673
10th October 1998	Version 1.0.0 Draft	SMG12 Meeting output version (Rome, Sept 1998. Inclusion of Tdocs 757, 759, 841, 728, 835, 726, 836, 815, 840, 803,851, 839, 745 Renumbering of scenarios and chapter numbers (not shown with revisions for ease of reading)
13th October 1998	Version 1.0.0 New Draft	Inclusion of Tdoc 98S781, Deletion of scenario 2 (formerly 3) and subsequent renumbering. Note on scenario 5 (formerly scenario 9)
3rd November 1998	Version 1.1.0	SMG12 Meeting output version (Montreux, Oct 1998. Inclusion according to the meeting minutes of Tdocs 891, 925, 930, 934, 935, 936, 942v2, 946, (Tdocs 916 and 917 not included due to no soft copy)
31st December 1998	Version 1.2.0	SMG12 Meeting Output Version (Castle Coombe, Nov 1998) Inclusion according to the meeting minutes of Tdocs 1073, 1124, 994, 1084, 1006, 1012, 1121. Deletion of scenario 5.

12th January 1999	Version 1.3.0	SMG12 Meeting Output Version (Heathrow, Jan 99) Relocation of scenarios (Previously Chapter 10, change bars not used) to new Appendix. Deletion of chapter on GSM capabilites (Previously Chapter 7, change bars not used) Removal of chapter 8,5 VHE section (Section 8.5) – Transferred to Open Service Document (Change bars not used) Removal of chapter 11 Protocol Architecture chapter (previously chapter 11 – empty chapter, change bars not used) Inclusion of the following Tdocs from the Heathrow meeting 96,19,20,80,81,42,82,46,95,74,75,84,60,61,93,102,99,68,76,100.
29th January 1999	Version 1.4.0	SMG12 Meeting Output Version (Walnut Creek, Jan 99) Inclusion of the following Tdocs according to the minutes of the above meeting. 226, 250, 241, 237, 186, 239, 259, 198, 188, 258, 145, 244, 233, 253, 211, 206
7th February 1999	Version 1.5.0	SMG12 Meeting Output Version (Stockholm, Feb 99) Change bars have not been used where items have been simply moved.

23.20 Appendix 1

Evolution Scenarios

The UMTS phase 1 network is planned as a direct evolution of the GSM core network. This implies that:

- the evolution takes account of both GSM and UMTS requirements,

- the modifications to GSM to create UMTS phase 1 should be limited to changes targeted at specific service and performance objectives.

These objectives can be achieved by creating a common stream of work items for both UMTS and GSM core networks. This is illustrated in Figure 47:
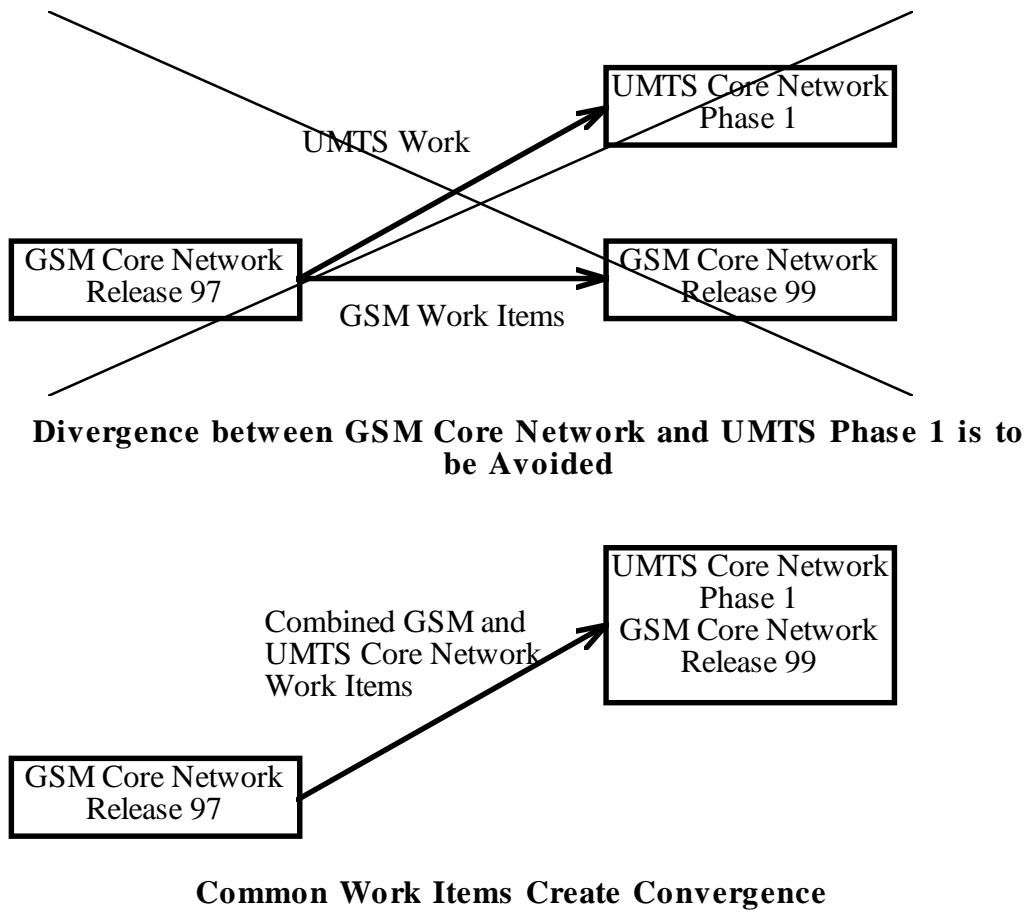
Divergence between GSM Core Network and UMTS Phase 1 is to be Avoided

Common Work Items Create Convergence

Figure 47 Common Work Items Convergence

In the following scenarios show possible evolution paths from GSM towards UMTS.

1.1. Scenario 1

The starting point in 2002: UMTS Phase 1

When UMTS Phase 1 will be ready for operation in 2002 it is very likely that the UMTS Terrestrial Access Network (UTRAN) will be interconnected with the GSM NSS. This is at least true for a scenario where the initial deployment of UTRAN will cover isolated islands (e.g. city centres, business areas, industrial plants, etc) while the overall (international) coverage will be provided by the GSM2+ infrastructure. This situation is given in Figure 49.
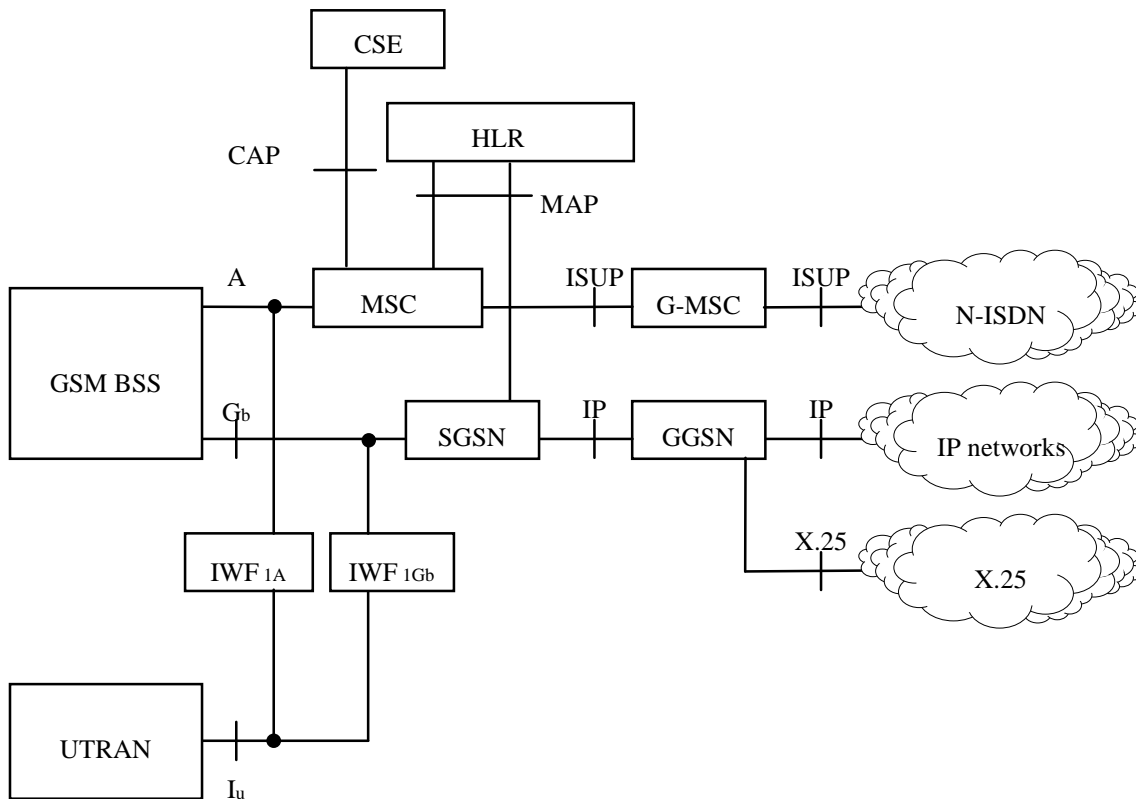
Figure 49: Interconnection of UMTS AN and GSM NSS via IWUs

1.1.1. Scenario 1 Opportunities

The approach depicted in Figure 49 show the use of GSM and GPRS specific Interworking Units (IWU) used to connect the UTRAN to the GSM/GPRS network.

The use of the UTRAN enables access to the broadband UMTS radio interface and offers a step towards network support of the full UMTS variable bit rate, asymmetric, multimedia capability.

As illustrated in Figure 49, UMTS users have broadband radio access to the IP-world for both the Internet and intranets via the GPRS nodes but will be limited to contemporary and developing GSM core network delivered capabilities.

1.1.1.1. Scenario 1 Multimedia Support

The ability to provide multimedia including different logical bearer for different media components, dynamic bearer release/re-negotiation etc may be supported in a limited fashion by the existing circuit switched GSM NSS or packet based GPRS nodes but developments are expected to realise the full potential.

1.1.1.1.1. Multimedia Over Circuit Switched GSM NSS

The GSM MSC would need significant development to support the 'real time' variable bit rate multi-media UMTS requirements but limited support is possible, it should be noted that although the circuit switched side of GSM NSS does not currently provide multiple bearers for different multimedia components, single bearer multimedia where different multimedia components are multiplexed to one bearer can be used in GSM NSS. An example of such specification is ITU-T recommendation H.324, which has been enhanced according to requirements of Mobile Networks. The recommendation specifies terminals which may carry real-time voice, data, and video, or any combination, including videotelephony and is also capable for multipoint configurations and dynamic addition and deletion of media components inside the bearer.

The single bearer would have fixed bit rate. Voice and data would have the priority and video would get what is left of the bandwidth. However, it could be possible to upgrade and downgrade the bearer depending on the required bandwidth and the radio conditions. The efficiency of the channel coding in single bearer multimedia is still for further study.

The effect of multiple bearers might be possible to get by using multiple calls from the same terminal. This could be used for media components which do not have any timing dependency or requirement for synchronisation.

1.1.1.1.2. Multimedia Over GPRS

The combination of UTRAN and GPRS offers a broadband radio access to the IP-world for both the Internet and intranets. The UTRAN can offer bearers fulfilling the multimedia requirements. It could be possible to evolve GPRS to be able to utilise the QoS levels provided by UTRAN. It could also be possible to use e.g. RSVP to guarantee the QoS inside the GPRS network and IP network to enable end-to-end high quality connection.

The access to internet makes it possible to use wide range of IP based multimedia applications. For example videotelephony over internet would be possible by using applications conforming to ITU-T recommendation H.323.

As stated there are a number of possibilities to ensure that GPRS meets the requirements of UMTS.

1.1.1.2. Multimedia support - Open Issues

There is still the problem how to handle multimedia including different logical bearer for different media components, dynamic bearer release/re-negotiation etc.

1.1.1.3. Scenario 1 Mobility support

When considering the opportunities and limitations applied to interfacing a UMTS UTRAN to the GSM NSS then serious considerations should also be given to the mobility requirements as well name:

- Location updating (routing area update GPRS)

- Paging

- Attach/Detach

- Handover

These requirements span the boundary between the UTRAN and GSM NSS with developments in one side impacting on the other. A good example is handover. For the GPRS part, this seems not to be an issue as handover is more a form of re-registration rather than an interface change. For the GSM circuit switched interconnect to the UTRAN then it is a very different matter. The forms of handover for the UMTS have not yet been finalised but factors such as forwards, backwards, soft handovers are all options.

Interconnection of the UTRAN to the GSM NSS would severely limit the applicability of these, unless dramatic changes were made to the GSM MSC as well.

It is imperative therefore that both service and mobility requirements that span the core and the access are considered when developing the UTRAN to GSM NSS evolution aspects.

1.1.2. Scenario 1 Related Actions

For the interconnections shown in Figure 49, the A and G_b interfaces refer to the interfaces as they will be defined by ETSI release 99 specifications. The Gb interface may include some modifications aiming at making IWF feasible. These modifications (if required) should be identified and specified These developments are completely in line with the UMTS Phase 1 as described in the UMTS Baseline document [UMTS 30.01v3.0.0].

It is still to decide whether it is desirable to upgrade the A/Gb interfaces inside GSM so that the GSM NSS-BSS interconnection could also benefit from the modifications needed for these interfaces when UTRAN is deployed.

Note: It needs to be checked whether G_b can provide at least services as proposed/requested by MPEG [SMG3 97S161] to efficiently provide multimedia services.

1.1.3 Alternate Access technologies to UTRAN

BRAN Access

The evolved GPRS network should allow for various radio access networks. As stated in [UMTS 23.01], a modular approach in UMTS evolution is recommended. This is also in line with the recommendation from GMM. Thus, the infrastructure domain, which encompasses the core network domain and the access network domain, allows for different access techniques/networks to be used. This scenario focuses on BRAN HIPERLAN 2 as a complement to GSM BSS and UTRAN in order to provide broadband data services in hot spot environments.

ETSI Project BRAN (Broadband Radio Access Networks) is developing specifications for broadband wireless access systems that support data rates around 25 Mbit/s for several applications. The primary focus for HIPERLAN 2 is to provide short range wireless broadband access with controlled quality of service for use within buildings and on-campus using unlicensed radio spectrum in the 5 GHz band. HIPERLAN 2 shall provide a range of 30-50 m in a typical indoor environment and up to 150-200 m in a typical outdoor environment.

The HIPERLAN 2 specifications are expected to be finalised during 2000, hence it will be possible to introduce BRAN access in UMTS phase 1**.**
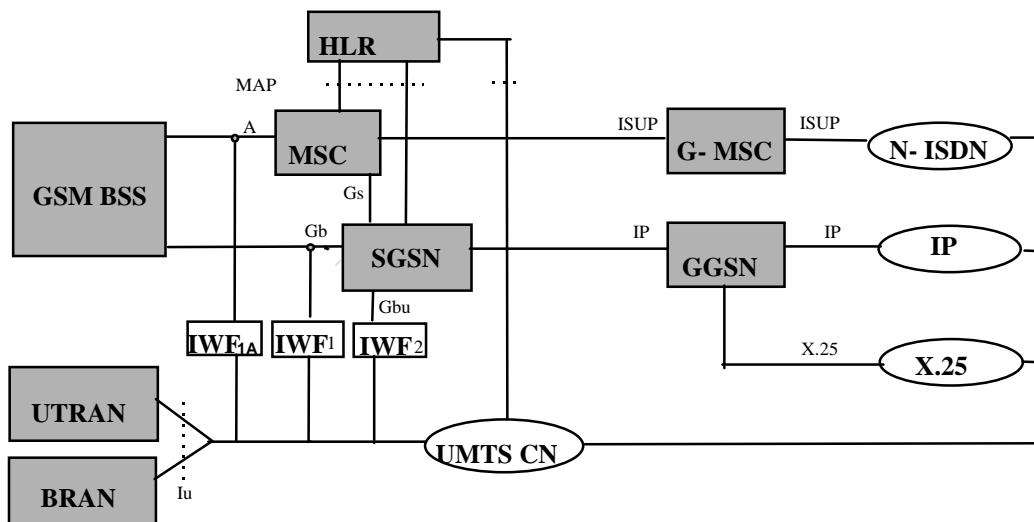

Figure 51 UMTS with BRAN access

(

1.1.3.1 Advantages of attaching BRAN to UMTS

- Provide UMTS with a complementary access technology for broadband data services for indoor and hot spots environments

- UMTS mobility infrastructure enables roaming also for HIPERLAN 2 terminals

- Easier multi-mode UMTS/HIPERLAN 2 service integration, enables e.g. network support for a one number service and the use of a common service platform

- UMTS subscriber management may be reused for HIPERLAN/2

- Enables the reuse of investments in core network technologies.

1.1.3.2. BRAN UMTS Interworking

UMTS will incorporate a new generic radio access network, the UMTS Radio Access Network (URAN). The URAN may include several different realisations, of which the UTRAN (UMTS Terrestrial Radio Access Network) is one. The Iu interface forms the boundary between URAN and the UMTS core network. By connecting BRAN to the Iu interface, BRAN will form a complimentary realisation of the URAN concept for broadband data services. UMTS interworking will provide BRAN with roaming support using the UMTS mobility infrastructure.
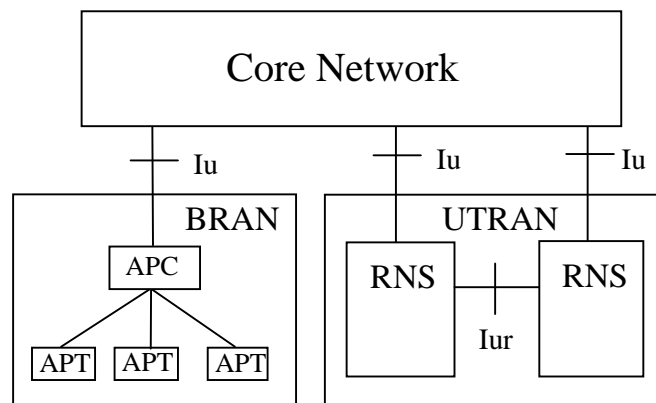

Figure 52: BRAN UMTS interworking.

A BRAN realisation of URAN should provide the same logical interface to the higher layers (i.e. layers belonging to the non-access stratum) as UTRAN. Hence, no changes in higher layers should be required. UMTS authentication, security and location management can be used over HIPERLAN 2. UMTS bearer setup requests should be mapped to the corresponding HIPERLAN 2 DLC connection. A USIM (User Service Identity Module) may be needed in a BRAN terminal supporting UMTS interworking. Handovers within a BRAN subsystem should be invisible to the core network. Handovers between UTRAN and BRAN, in case of dual mode terminals, should be supported via the core network.

1.1.3.3. Related Actions

The same protocols over the Iu interface should be used for both UTRAN and BRAN. However, some impact of connecting a broadband access network, capable of bit rates in the order of 100 Mbit/s, can be expected. Therefore the Iu must be flexible and future proof. Guidance and co-operation with ETSI BRAN on these matters should be sought.

1.2. Scenario 2

This scenario emphasises the existence of two fundamentally different and independent technology paradigms in communications: One PSTN/ISDN paradigm and one IP-paradigm. By recognising this the UMTS core network in this scenario is logically divided into two parts, one part optimised towards the PTSN/ISDN paradigm and its services and the other part optimised towards the IP-paradigm and its services.

This scenario also avoids any mandatory ties between the network layers (L3) and the underlying transport layers (L1/L2) within the core network. From a services perspective this creates an optimal architecture which is open with respect to networking principles and selection of protocols and transport solutions. It also allows for deployment of non-PLMN specific standards and PLMN-external networks to be used for inter PLMN-communication in conjunction with e.g. roaming.
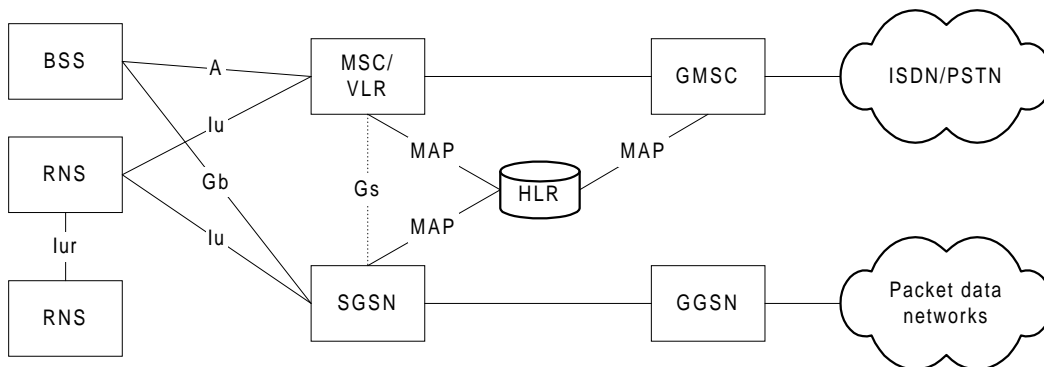

Figure 53 Reference model (CAMEL components not shown)

The logical separation of the circuit and packet switched domains still allows, for example, an implementation where MSC/VLR and SGSN are integrated in the same network element.

Compared to the scenarios where UTRAN is connected to GSM core network via interworking functions, the core network nodes in this scenario interface UTRAN directly over the Iu-interface. New network capabilities are added for support of e.g. multicalls and IP-QoS.

1.2.1 Iu Interface

The logical separation of core network places some requirements for the Iu interface, UTRAN functionality, and mobility management. The requirements to Iu interface in this architecture scenario are:

- Common transport layer is defined for both UTRAN – MSC/VLR and UTRAN – SGSN interfaces.

- Common RANAP protocol is defined by which MSC and SGSN can request services from UTRAN. RANAP is required to provide efficient support for both PSTN/ISDN domain and IP domain. The bearer attributes and procedures are for further study.

- RANAP shall also have direct transfer functionality that is used to transfer L3 signalling transparently between MS and core network. This signalling includes L3-MM Mobility Management (between MS and both domains), L3-CM Connection Management (between MS and PSTN/ISDN domain) and L3-SM Session Management (between MS and IP domain).

- UTRAN (RNC) shall have the capability to route L3 signalling messages to the correct core network entity (MSC or SGSN).

- Transport network signalling protocols (ALCAP) shall be defined for setting up connections over the Iu interface. The ALCAP protocols are preferably protocols standardised e.g. by ITU-T, and they may be different for the two instances of Iu interface if e.g. different ATM adaptation layers are used. If several packet data streams are multiplexed together on the Iu (for example, on one ATM VC), a frame handling protocol (FHP) for doing this shall also be defined.

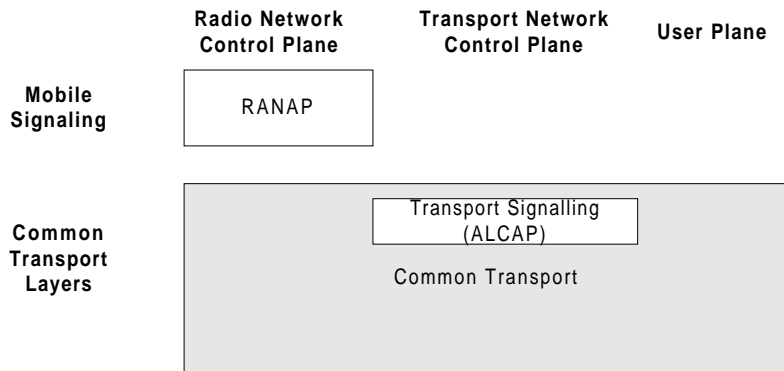The Iu interface requirements are illustrated in Figure 54.

Figure 54 Iu interface requirements and principles

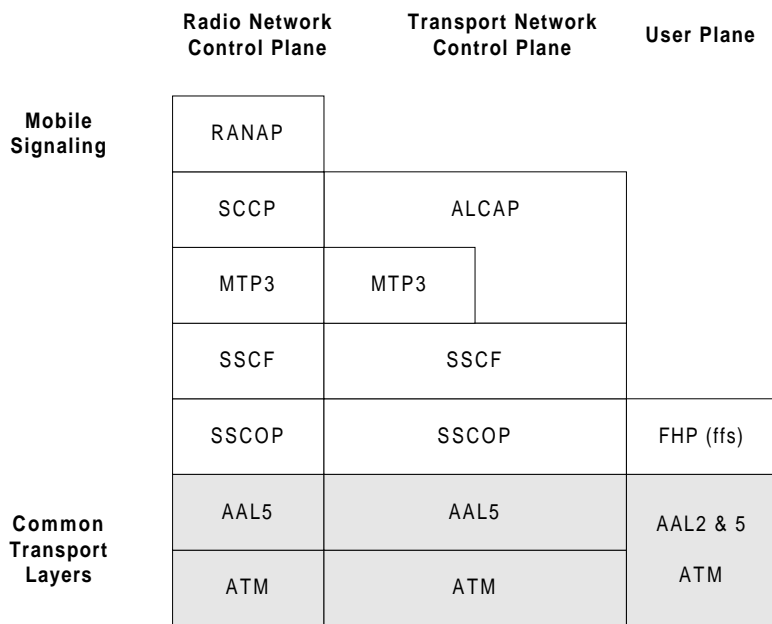Figure56 illustrates an example of the Iu interface protocol structure.

Figure56 An example of Iu interface protocols

In addition to the Iu protocols shown in Figure56, user plane L2 protocol(s) corresponding to GSM RLP and LLC are required to support reliable error free transmission between MS and core network for services such as non-transparent data service.

1.2.2 Network Layer View (Layer 3) of Core Network

From a network layer (L3) point of view this scenario is characterised by two completely different domains, one circuit mode ISDN/PSTN domain and one packet mode IP domain as illustrated in Figure 58. Separating the two domains avoids compromises, in the standardisation and in the implementation, between the fundamentally different IP and ISDN/PSTN paradigms which otherwise might increase primarily time to market but also complexity costs. Each domain can also evolve independently of the other in the future UMTS evolution, which is of particular value since the IP paradigm is expected to evolve extensively.

The ISDN/PSTN core network domain provides connectivity for N-ISDN services towards ISDN/PSTN and other PLMNs. A multitude of protocols (e.g. ISUP) exists which may be used in this domain, but the selection of protocol is not a subject for standardisation. The IP core network domain is optimised for providing IP end-to-end services with IP QoS. Since IP is an international standard, with no national dialects, IP is the suggested network protocol for this domain.
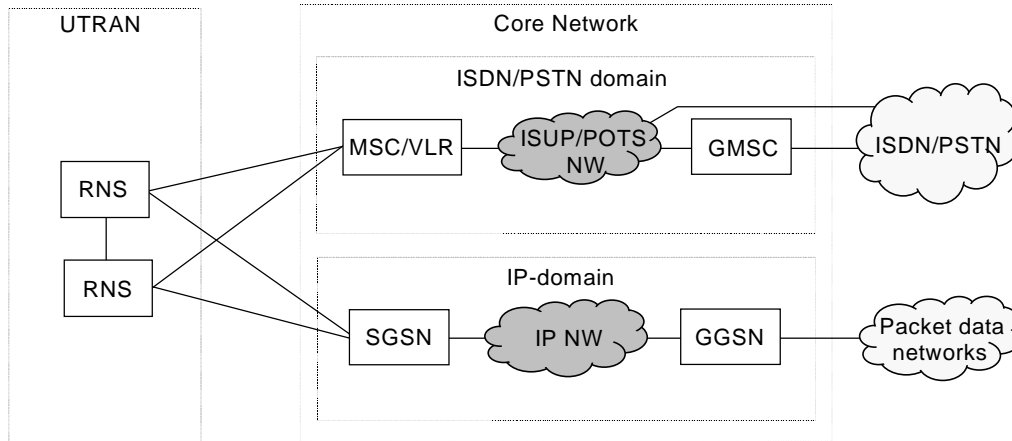

Figure 58 Simplified network layer view in the UMTS core network

1.2.3 Core Network Transport (L1/L2)

The transport technology within the core network can be selected independently of the network layer as illustrated in Figure 60. The selection is not a subject for standardisation. The obvious alternatives in the circuit switched domain are STM/TDM and ATM. In the packet data domain the lowest standardised protocol layer is IP (Gn interface) just as in GPRS, leaving the operator a multitude of choices in building the backbone network. This makes it possible to tailor the transport networks of each PLMN individually in order to achieve the most optimal transport solution for each operators business. Decoupling the network layer from the transport layer adds flexibility to the network architecture and allows new transport technologies to be deployed as they emerge, without having to modify the network layer.
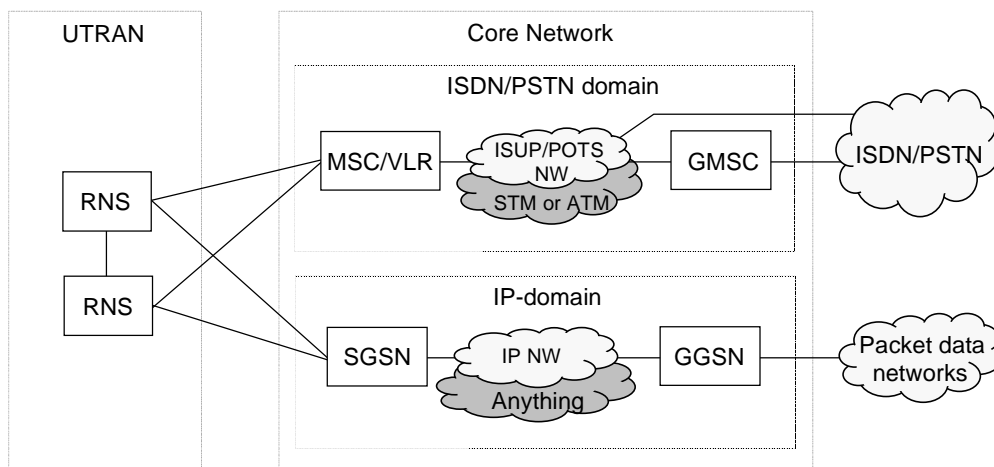

Figure 60 Simplified transport layer view in the UMTS core network

Integration of the transport network between the two core network domains on layer 1 and 2 is possible, e.g. by means of a common ATM transport network. Such integrated transport solutions may also include (parts of) UTRAN and other, non-UMTS networks of an operators business. Integrating the transport network is a matter of implementation, however, and is not a subject for standardisation.

1.2.4 Mobility Management

MSC/VLR and SGSN have their own independent mobility management functions. This means, for example, that the MS may register independently in each core network domain and both MSC and SGSN maintain subscriber location data.

MS has two largely independent MM instances with corresponding peers in each core network domain. Although the MS may thus have two simultaneous MM connections, one towards each core network domain, a single RRC connection is used between the MS and UTRAN (serving RNC) enabling co-ordination of all transactions.

In order to have a common functional split between UTRAN and both domains of the core network, the MM procedures towards each part of the core network can be harmonised. This is proposed to be done in a way that is based on the principles associated with the MM procedures between the MS and the circuit switched core network in GSM. This would imply that the possible MM states are detached, attached (idle) and active. The location of an idle MS would be tracked with the accuracy of a location area (or its UMTS equivalent). UTRAN can handle independently the more accurate tracking of the MS during an established MM connection, without involvement of the core network.

In order to facilitate interworking with GSM networks, it is important that some identities and area concepts remain backward compatible to the corresponding parameters in GSM. Specifically this concerns IMSI, TMSI, PTMSI, LAI and RAI.

The need for co-ordination between the MM entities is for further study. Possible options are:

- No co-ordination i.e. no Gs like interface

- Co-ordination to achieve optimisation of air interface procedures (Gs like functionality)

1.2.4.1 Paging

MSC and SGSN perform paging independently and separately from each other. Necessary co-ordination functionality is located in UTRAN: Either MS listens to paging channels even in active mode, or a common identifier such as IMSI is used by both core network entities for co-ordination purposes.

1.2.4.2 Handover and serving RNC relocation

Handover is handled within UTRAN without involvement of the core network by utilising the Iur interface between RNC:s. Relocation of the serving RNC and associated Iu interface(s) in order to optimise transmission resources is seen as a conceptually separate procedure that may, or may not, take place in conjunction with a handover.

However, handover between UMTS and GSM networks will need involvement from the core networks.

1.2.4.3 Mobility within the core network

In order to provide as much service continuity as possible for subscribers roaming to GSM networks, or experiencing handover to GSM networks, the GSM MAP procedures are used for interworking with GSM networks. The GSM procedures are also reused to the largest possible extent for roaming and handover within and between UMTS networks. This will also facilitate upgrading of GSM networks to GSM/UMTS networks.

1.2.5 Separation of Switching and Control

The protocol stacks for the user and the signaling plane in this section are examples of protocol stacks that result when the principle of separation of switching and control is applied to the scenario described in section 1.2. Scenario 2

1.2.5.1   Signalling plane protocol architecture

Figure 62 below displays a protocol architecture for the signalling plane, taking into account the separation of switching and control in the core network. In such a network, a variety of servers will be accessed, depending on the type of service required by the user. Consequently, the signalling plane protocol architecture must support the ability to route signalling messages to the appropriate server.
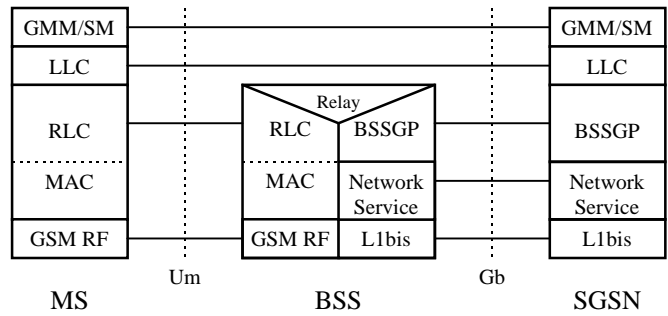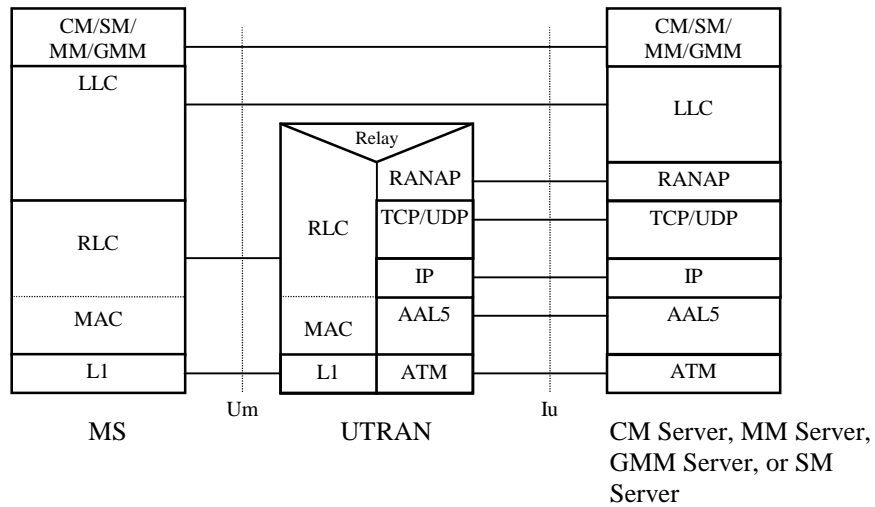

Figure 62: Example Signalling Plane Protocol Architecture MS-UTRAN-CN

Legend:

L1: Layer 1 of the air interface

MAC: Media Access Control

RLC: Radio Link Control

LLC: Logical Link Control, provides a reliable logical link between the MS and the core network

ATM: Asynchronous Transfer Mode

AAL5: ATM Adaptation Layer 5

RANAP: Radio Access Network Adaptation Protocol

TCP: Transmission Control Protocol

UDP: User Datagram Protocol

IP: Internet Protocol

MM: Mobility Management for circuit-switched traffic

GMM: GPRS Mobility Management for packet-switched traffic

CM: Connection Management

SM: Session Management

Focusing on the Iu interface in this architecture, the CM/SM/MM/GMM layer provides the messages to support the Connection Management, Session Management, circuit Mobility Management and packet Mobility Management procedures required in the network. The next layer down, the RANAP, routes these messages to the appropriate server nodes in the core network and from those nodes back to the UTRAN. Moving down the stack, the combination of TCP or UDP with IP provides a network service that allows routing of signaling messages to the appropriate server elements in the core network. Other examples of realisation of network service to facilitate routing of signalling messages could be ATM SVCs between network nodes. Finally, an ATM-based interface is used at the lower layers of this interface. This common layer carries signalling for circuit and packet-switched traffic, as well as user data for both modes. This common use of ATM at the lower layers of the Iu interface is reflected in the user plane protocol stacks in the following section.

1.2.5.2 User plane for the ISDN/PSTN domain

The user plane protocol stack for traffic in the ISDN/PSTN domain is shown below in Figure 63. The common ATM layer described above is again shown here at the bottom layer of the Iu interface. For the ISDN/PSTN domain, typically voice, AAL2 is used as the ATM Adaptation Layer.
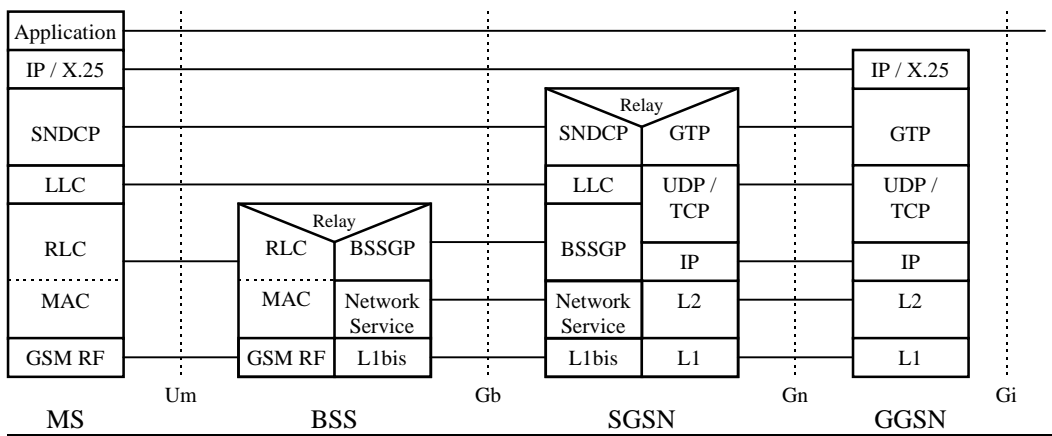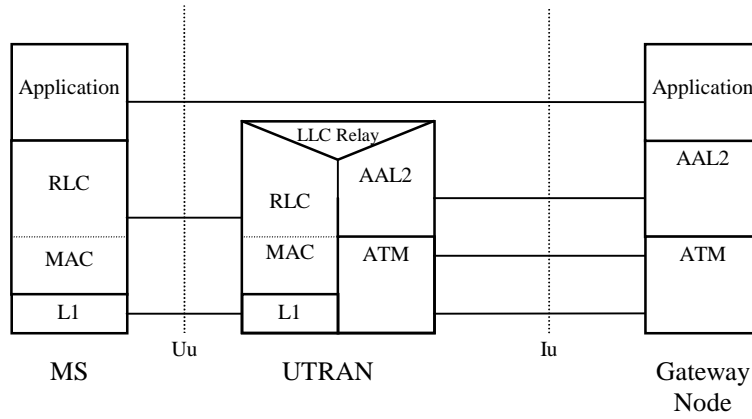
Figure 63 Example User Plane Protocol Stack for the ISDN/PSTN Domain

1.2.5.3   User plane for the IP domain

For the IP domain, IP can be used in the Iu interface. Figure 64 below displays the user plane protocol stack for the IP domain. Application traffic is tunneled through the core network to the UTRAN using an evolved version of the GPRS Tunneling Protocol, denoted here as GTP+. For IP traffic, AAL5 is generally an appropriate ATM Adaptation Layer. Once again, ATM is used as a common lower layer on the Iu interface.
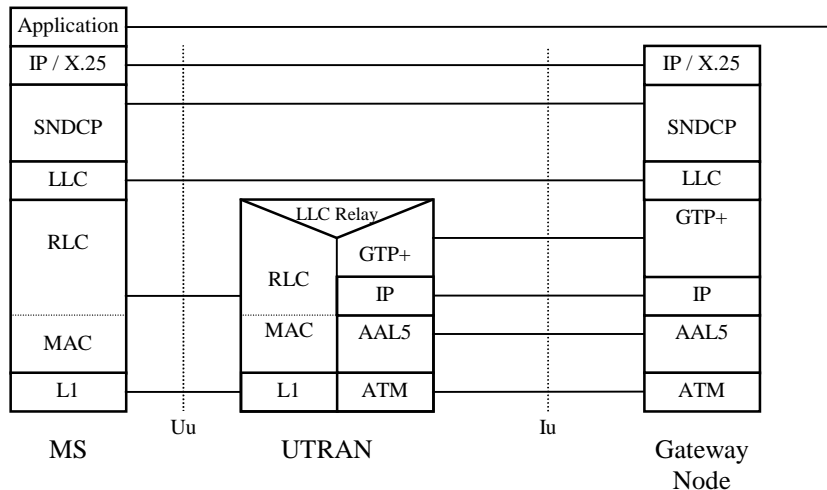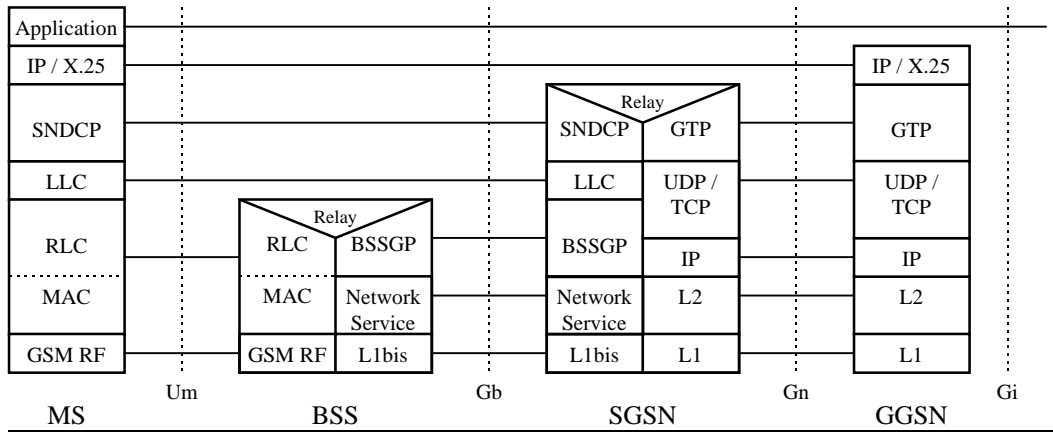
Figure 64 Example User Plane Protocol Stack for the IP Domain

A variety of transport technologies could be used as the layer 3 transport in the core network for IP domain traffic. Since the Iu interface uses ATM, a transport switching node can be placed at the edge of the core network to interwork between the ATM used on the Iu interface and a different layer1/layer 2 combination within the core network. Figure 65 below displays such a configuration, with PPP (Point to Point Protocol) used as a specific example for a possible layer 2 protocol.

Figure 65 Example Alternative User Plane Protocol Stack for the IP Domain

1.2.6 Opportunities

Optimised for both N-ISDN and IP-services

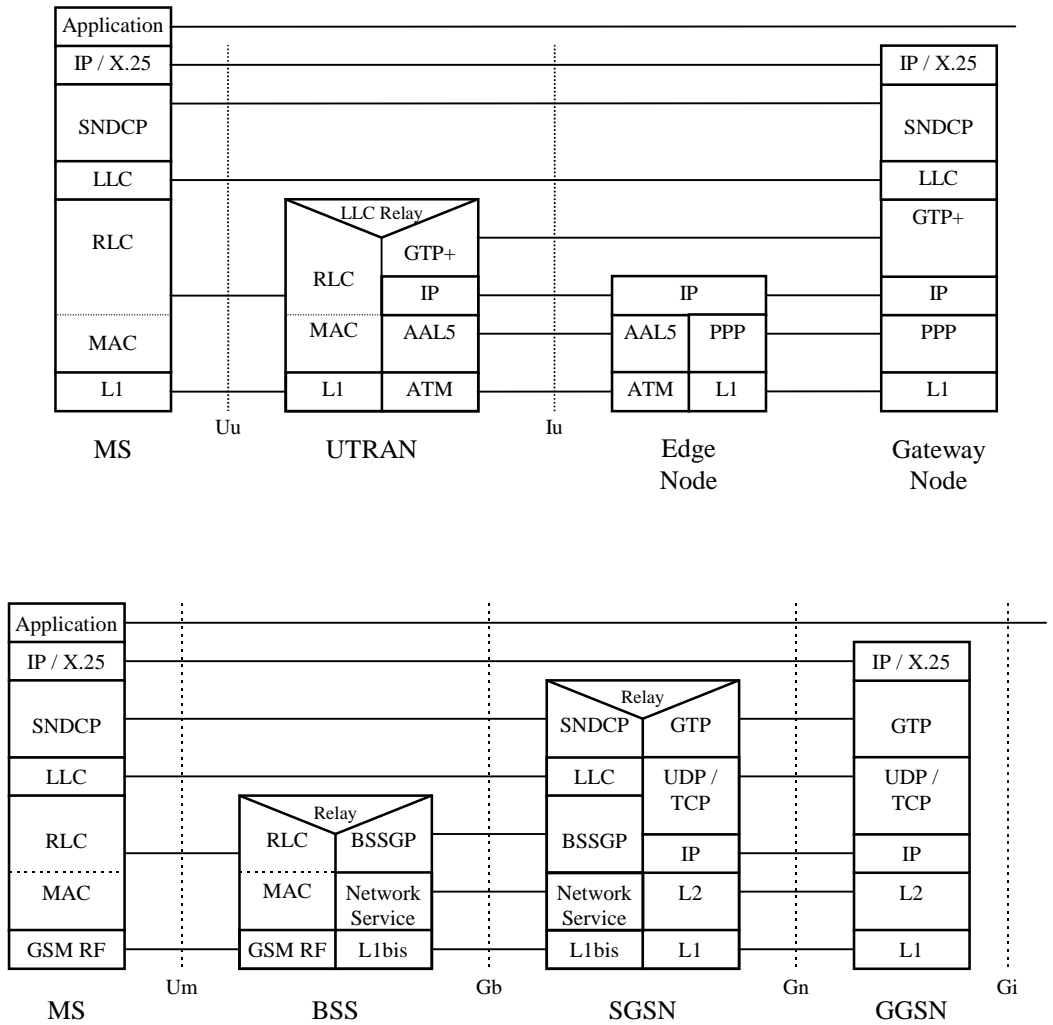Offers support for multimedia according to main steam standards such as H.320 and H.323, as well as support for main stream multimedia solutions within the IP-world, based on Integrated Services and DiffServ as defined by the respective IETF WG.

Based on multi technology standards:
- Flexible and open with respect to networking principles and transport solutions.
- Supports mixed PLMN/non-PLMN networking solutions.
- Supports independent evolution of individual PLMNs (no 'big bang' for synchronised evolution).
- Supports integrated transport solutions.

Relies on proven and well functioning standards for support of N-ISDN services.

Results in manageable migration scenarios.

Avoids compromises between the two fundamentally different IP and ISDN/PSTN paradigms.

Results in manageable interworking with GSM networks.

Results in manageable upgrading of GSM core networks to GSM/UMTS core networks.

1.3 Scenario 3

Integration of circuit and packet switched transport in the UMTS network

The UMTS starting architecture shown in Figure 49 *and* **Error! Reference source not found.** *of 23.20 would allow to access a wide range of data* services; in particular it would make possible to have an efficient packet-based access to the Internet on a mobile terminal.

Some problems could anyway be highlighted if considering the merging of GSM and current standardisation of GPRS the target for UMTS deployment.

If market forecasts depicting for next years a tremendous increase of data transfer volume are realistic, during the next decade we will probably witness a communication environments where common people are Internet users, where the exchange of e-mails on mobile terminal is no longer a privilege of IT-skilled people and where video, pictures and graphics are a substantial part of the information we exchange, information retrieval from a remote database is the normal way to solve everyday problems.

In such a scenario where the growth of IP will probably play a substantial role, the evolution of the IP-based technology will allow an efficient support of multi-media applications (music and sounds, voice, video, electronic blackboard etc..), the Internet Protocol being no longer used for best effort services like WWW surfing, but also for different QoS, sophisticated applications.

Nevertheless, it is nowadays impossible to have an exact evaluation of how fast the Internet community will reach the goal of the efficient support of real-time services over IP; technologies like Layer 3 Switching and "band reservation" policies on links shared by different applications seem to be promising but is difficult to predict when the technology will be proven enough to allow voice transmission over a geographical IP network.

At the same time the basic telephony services will probably continue being the main source of revenues for operators during next years making the scenario where all services are migrated over the packet switched part of the mobile network quite unrealistic in a short term view.

In other words, while it is quite easy to predict a scenario where the volume of data traffic transferred in a mobile network is largely bigger than the traffic volume due to voice traffic, it is pretty difficult to predict when this overtaking will be completed during next years.

It is much more likely that circuit-oriented services and packet-oriented services will coexist at least during first years of UMTS deployment.

In the following some arguments supporting a solution where packet oriented transport and circuit oriented transport are integrated in a common transport platform are given.

- If PCM-based GSM networks and packet-based GPRS networks will be maintained separated, network operators will be called to guess what the request for packet oriented services could be and try to dimension the packet network based on future market demands. A possible way out from this undesired perspective is starting a real integration of GPRS and GSM as a target for the evolution of both networks; the realisation of a common platform supporting both packet and circuit networks is a possible way to migrate in the future the traffic load from one technology to the second one, according to market needs.
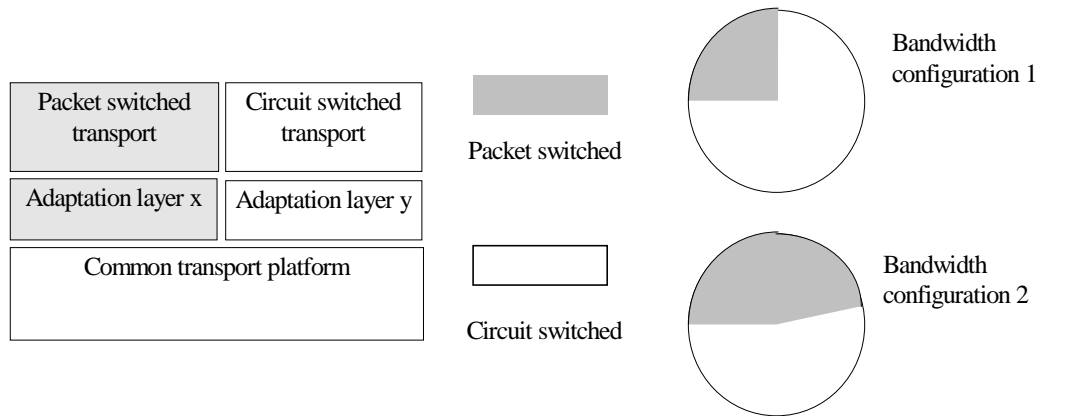
Fig 66

The presence of a common transport platform as the target for UMTS transport would allow to assign the band offered by the "common platform" on demand according to market needs; the flexible allocation of bandwidth could be used to re-assign the terrestrial resources on demand when needed or depending on peak hours on a daily basis.

- The same scenario would allow in the future to easily migrate services from the circuit-switched platform to the packet switched one (and even the opposite if needed), as soon as the evolution of packet network will offer the same performances in terms of delay and jitter. This way this integrated solution would pave the way for a scenario where all user traffic and signalling is carried by the packet network (as expected by many telecommunications gurus) allowing at same time to keep alive circuit switched services and applications as long as desired.

- An integrated circuit and packet transport is certainly a good step in the direction of GSM and GPRS services co-ordination; possible solutions in this sense could arise from:

    1. make circuit and packet data flows cross the network through the same nodes, where some flow-control and re-synchronisation could be performed

    2. make the packet-switched control acting as a slave and circuit-switched control as a master (or vice-versa) in order to co-ordinate bearers for the achievement of a common service

    3. pursue the evolutionary target of a signalling architecture common to both circuit and packet networks; the last one being probably the best candidate for the support of this particular kind of data exchange.

10 3.1 ATM based common transport platform

At least two service categories can be identified in Third Generation mobile networks: the circuit based voice services and the IP based Internet (http, e-mail, ftp, etc) services.

It is likely that multimedia services in UMTS should be standardised and handled according to emerging multimedia standards; H323 for example defines audio and video telephony on the Internet independently of network layer and data link layer.

As a consequence multimedia services could be potentially run on top of circuit as well as packet switched platform, based on efficiency and performance considerations.

At the same time it is necessary to take into account that the Internet (i.e. the IP protocol) seems to increase every day the amount of multimedia, so representing an attractive reality to be followed.

In order to move towards a future infrastructure improving the spreading of Internet and yet ensuring the same quality of current telephony systems, a common transport platform based on ATM using a doubled protocol stack is proposed.

The proposed transport scheme and the related network architecture aims at exploiting fully IP routing capabilities and at the same time realise the integration of circuit and packet transport in the UMTS network.

Having in mind the above requirements and speaking in terms of transport capabilities, the ATM is probably the only well-proven technology able to offer the necessary flexibility.

1.3.1.1. Use of a simplified ATM QoS scheme

A possible solution to the problem of supporting voice circuits and IP services is to share the bandwidth offered by an ATM trunk in two parts.

In this scheme, the connection-oriented services like voice would make use of a circuit-oriented transport scheme based on ATM/AAL2 (see the end of this section) Virtual Circuits in order to insure the QoS necessary for each transaction, while IP services would be based on a connectionless transport. It is for further study whether new services like real time video, videoconference etc. could be more efficiently supported by the circuit oriented transport plane (by using ATM connections with higher bit rates) or by the packet oriented transport plane (e.g.. relying on QoS over IP techniques).
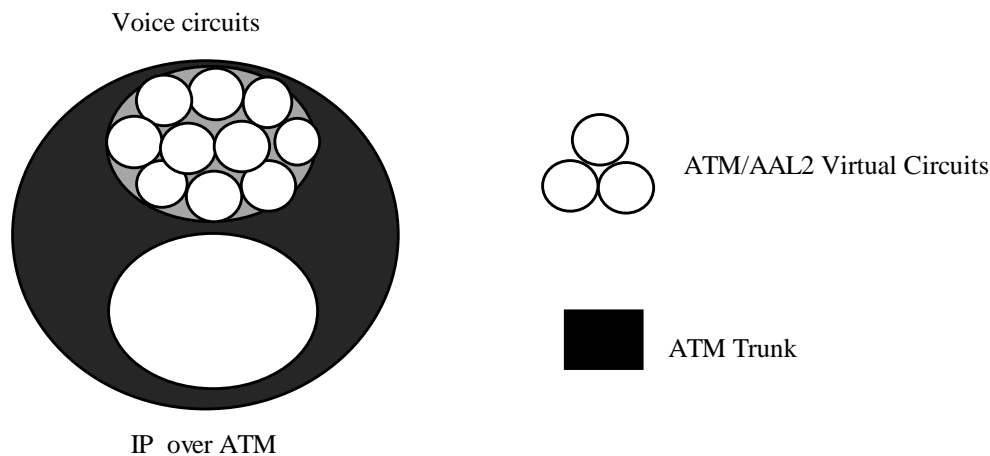
Voice circuits

ATM/AAL2 Virtual Circuits

ATM Trunk

IP over ATM

Figure 67

The "classical IP over ATM approach" (where the IP datagrams make use of ATM as a pure point-to-point Layer 2 without using ATM signalling or routing) could be suitable for IP services [i].

This transport scheme could be realised by giving voice circuits the highest possible priority into the ATM switches, meaning that IP traffic would be allowed to use the all the bandwidth left by voice traffic. In such a QoS management scheme, the IP packet delivery is best-effort from the ATM point of view, meaning that differentiation between different IP flows should be left to IP QoS policies (e.g. differentiation between datagrams belonging to different applications is already implemented in last generation IP routers).

As an alternative, the circuit-oriented traffic and the packet-oriented traffic could share the ATM trunk bandwidth statically, meaning that both voice and IP traffic would be given from the beginning a guaranteed bandwidth that cannot be overcome. This would probably allow to have a better control of QoS parameters for the packet-switched transport part, the main drawback being that no statistical multiplexing exists between IP and voice traffic and a lower degree of trunk efficiency should be accepted.

This first possibility for the proposed scenario is probably the most likely feasible, when considering a migration path from GSM/GPRS networks towards UMTS.

The circuit-oriented part of the network would in fact inherit GSM voice traffic and (when possible) the evolution of GSM control procedures (including the circuit-oriented signalling), while the packet oriented part would represent an evolution of the GPRS network.

The proposed transport solution would present the big advantage of starting the integration process independently from the degree of evolution reached by GSM/GPRS networks towards UMTS. It would just present the sigle drawback of an early decision on adopting ATM as the basic transport technology for UMTS.

1.3.1.2 Use of ATM QoS differentiation for signalling

If pushing a little further the concept of sharing the ATM bandwidth between different data flows, it is possible to consider a more advanced ATM QoS management scheme.

This way in addition to a circuit-oriented and a packet oriented part, we could imagine an ATM virtual path devoted to additional transport classes, like a specific signalling transport class.
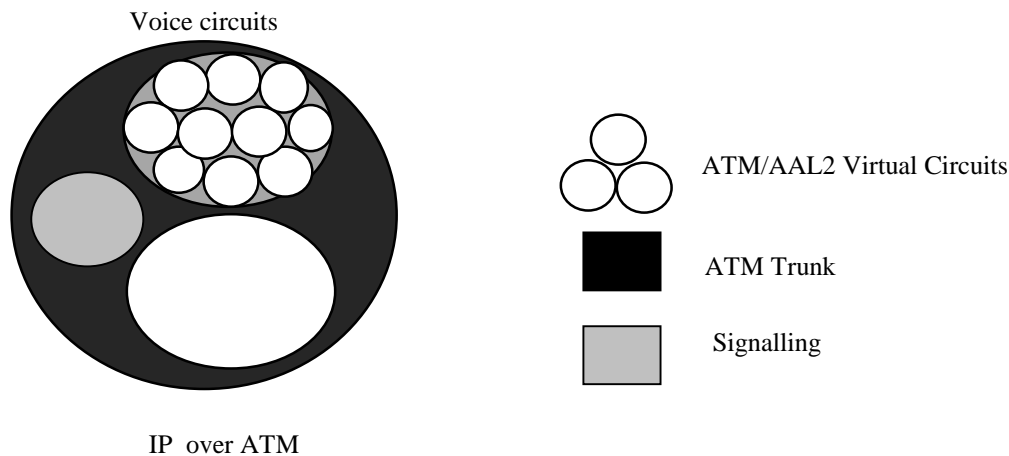

Figure 68

The ATM bandwidth sharing between different applications could be static or dynamic again, as explained in the previous section.

This solutions seems to be more realistic in a long-term perspective as it shows some advantages just in the case of a full integration of the circuit and packet part of the system.

The presence of a "signalling transport" class would in fact imply to have common control procedure for the evolution of both GSM and GPRS networks.

This means that such a transport scheme will be suitable for the moment in time where the evolution of GSM and GPRS networks will be integrated not just from a transport but also from a signalling point of view, making possible the creation of mixed circuit and packet based services.

1.3.1.3 Considerations on the use of ATM

The proposed approach seems to be reasonable if considering the following issues:

- a technology to efficiently support integrated voice-data-multimedia services is needed in Third Generation systems

- ATM technology seems to have the right answers to this request of flexibility and it is a well-proven technology from the data transport point of view: the computer network world has already adopted ATM as one of the standards for LAN and WAN implementation

- IP has entered the TLC market, as operators and manufacturers foresee a new business in offering Internet access through mobile and fixed telecommunication networks, but technology is not ready yet to support efficiently real time services with a pure IP network

Following this approach, the ATM can be introduced in the UMTS network architecture in the most proven way:

1. supporting the IP protocol and re-using the experience of computer networks (it is reasonable to consider that about 40% of IP traffic world-wide is currently transported by ATM networks)

2. allowing to create a future-proof transport technology: it is uncertain if during next years the packet based IP will be able to support voice services efficiently rather than TLC network will continue to rely on circuit switched transport technology to provide high QoS. The proposed approach allows UMTS networks to evolve in both directions.

1.3.2 Use of IP

1.3.2.1 IP networking

Both the "simplified" and the "advanced" use of the ATM proposed before have in common the same use of IP as the basic packet transport protocol.

The proposed packet transport architecture in fact makes use of ATM as a pure Data Link layer, using ATM "pipes" as a point-to-point trunk and ATM switches as semi-permanent connections, while relying on IP for networking purposes.

This solution is somewhat different from the GPRS architecture, where IP networking is used just between GSN nodes, using different protocol in order to route packets to the correct Gb interface. In addition the need for supporting both IP and X25 in GPRS make necessary the use of a "tunneling protocol" in order to allow both protocol sharing the same transport infrastructure. As a consequence IP datagrams crossing the Gn interface between GGSN and SGSN are tunnelled firstly into a GTP envelope, then into an IP datagram again.

If it is acceptable that X25 has a very low profile in UMTS and that IP is the main data protocol to be supported, it is probably better to consider a network infrastructure optimised for this second one.

It is ffs where the use of IP as a networking protocol should be stopped in the AN in order to start the interworking with radio-related protocols like the RLC (Radio Link Control).

The choice depends on the use of diversity: if the RLC layer (or the radio-related protocol layer supporting diversity) is closed in the RNC, the effect would be having the possibility of recombine different diversity branches up to RNC level.

Closing the RLC in Node B would mean that the Iub interface would not include diversity for packet transport.

1.3.2.1.1 Use of IP networking up to RNC level

This would imply to rely on IP for packet networking functions in the network infrastructure and up to the RNC, where the interworking with radio-specific protocols would take place.

Please note that in the following picture and following sections the **UMSC** (UMTS MSC) term is used to address the generic Core Network node responsible for both circuit and packet switching (see Physical Architecture section).
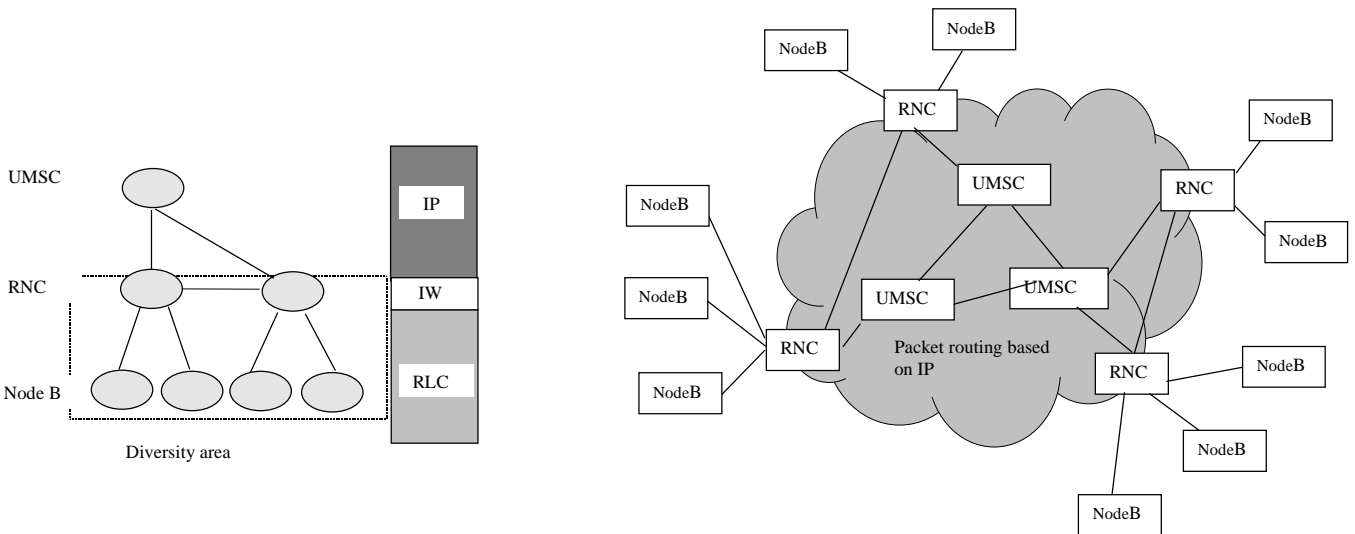

Figure 69

This would correspond to a packet transport protocol stack similar to the following one, given as an example.
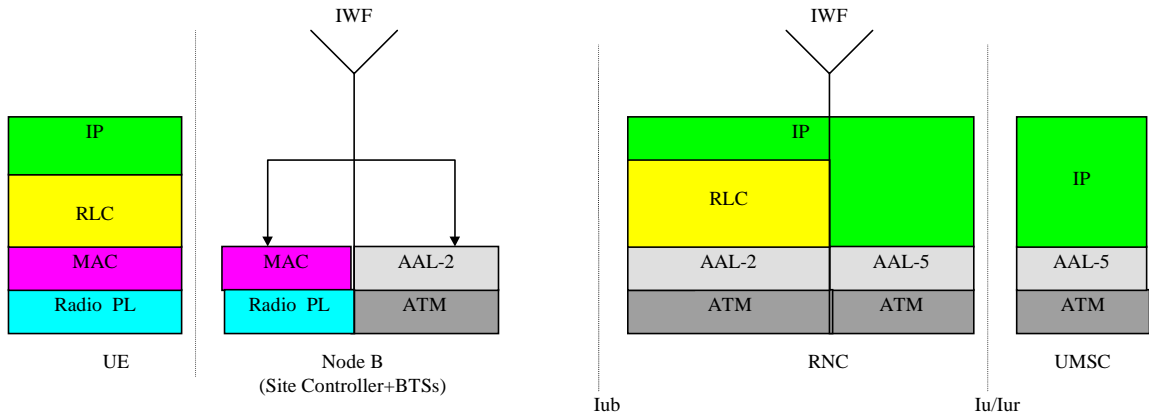

Figure 70

1.3.2.1.2 Use of IP networking up to Node B level

This would imply to rely on IP for packet networking functions in the network infrastructure and up to the Node B, where the interworking with radio-specific protocols would take place.
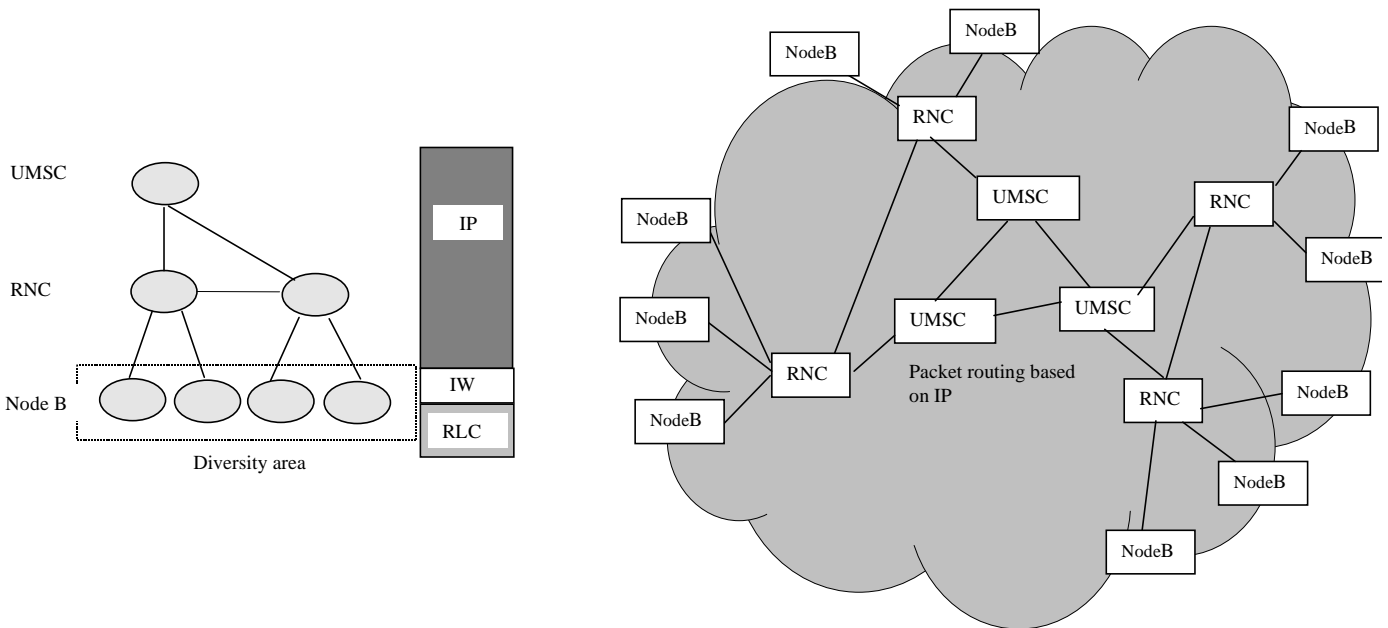

Figure 71

This would correspond to a packet transport protocol stack similar to the following one, given as an example.
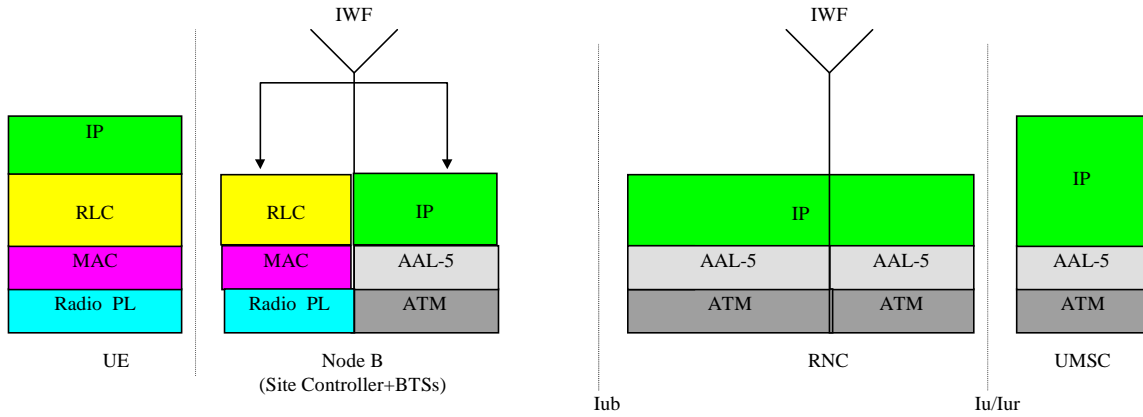

Figure 72

Both alternatives seem to be possible, as SMG2 has not taken jet decisions concerning the use of diversity for packet transport, while an extensive use of diversity for circuit oriented traffic and voice in particular is envisaged.

1.3.2.2 Consequences of the use of IP networking

If considering for UMTS the possibility of a packet routing strongly based on IP networking functions, some considerations can be done:

- the IP routing mechanism allows an automatic optimisation of network paths. This means that in a mobile to mobile data session packets would no longer need to be sent up to the GSN nodes in order to be routed, as they will automatically use the most direct way to the destination using IP routing tables. Therefore all cases of local data traffic could benefit from shortest paths and lower processing time.

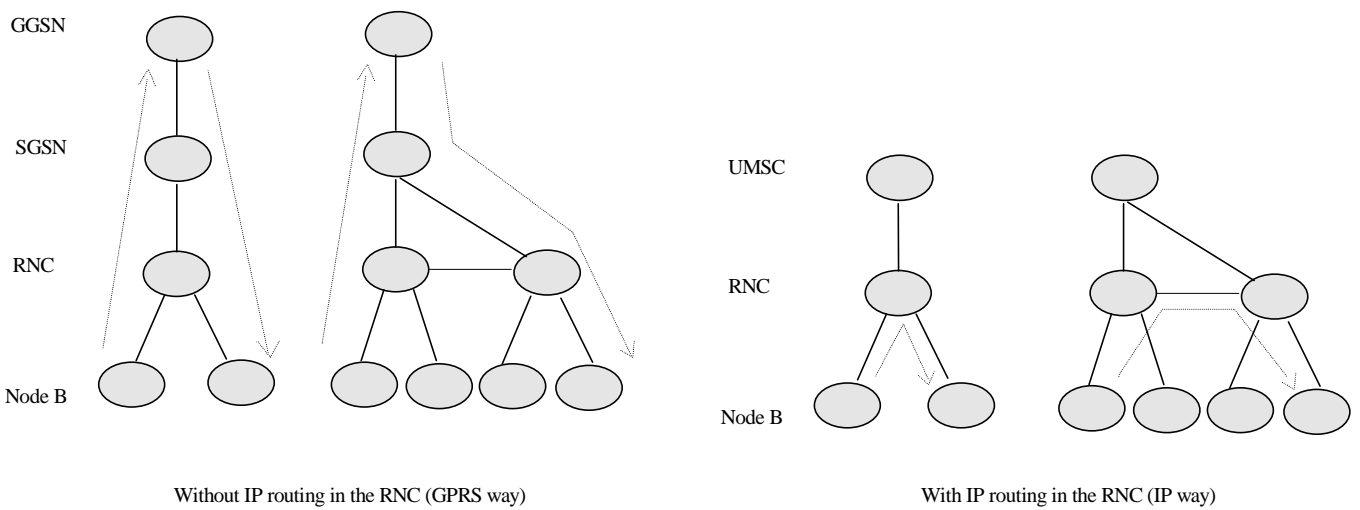Without IP routing in the RNC (GPRS way)   With IP routing in the RNC (IP way)

Figure 73

- An IP-based UMTS packet network would benefit of the flexibility, simplicity in maintenance and reconfiguration that have made IP networks so popular.

- An IP-based and IETF-compliant packet network would allow to introduce from the beginning the new technolgies under study in Internet standardisation groups and dealing with Mobility, QoS enhancement, security etc.. If IP solutions specific of a mobile network would be adopted most of these arguments would need to be re-investigated by SMG resulting in a slow response to market needs.

- If an IP-based packet network for UMTS is used, the cost of introducing a new service running over IP platform would be basically limited to the purchase of a server, with no basic impact on the infrastructure independently from server characteristics and physical location.

Having in mind the above considerations, it is probably acceptable that is not correct to propose the current status of GPRS standard as the only alternative for the packet switched data transport in UMTS.

Operators should have the freedom to choose an evolution towards UMTS with or without the adoption of GPRS release 1997 in their networks; they could in fact consider more convenient to wait for the services offered by GPRS phase 2.

It is certainly necessary to consider a migration path towards UMTS passing through the GPRS implementation, but it should be clear that GPRS as it is today doesn't represent the best level of optimisation according to UMTS requirements and the wish of having a future-proof network solution.

In particular:

- The GPRS transport protocol stack has been designed in order to make possible the re-use of a GSM BSS, then at least a part of it is certainly not optimised for the UTRAN.

- The GPRS standard is currently proposing a solution where circuit and packet transport network are separate, then a costly solution in terms of deployment and management from an operator perspective.

- The GPRS network is entirely based on equipment developed ad-hoc for a mobile network, while the IP technology adopted in fixed data networks offers plenty of commercial solutions already tested in thousands of networks world-wide. In particular there is no reason for using a networking protocol different from IP at the SGSN – BSC and possibly BSC – BTS interfaces.

- The GPRS standard seems not to take into account last evolutions of IP standard like Mobile IP, as few contact points exist between ETSI ad IETF (Internet Engineering Task Force).

1.3.3 Physical architecture

In the following some guidelines concerning a network architecture that could lead to a real integration of circuit and packet switched services in UMTS are given.

The arguments given only refer to the user plane, i.e. only user data transport problems are taken into account, while the control plane aspects and mobility management aspects are not modelled in detail.
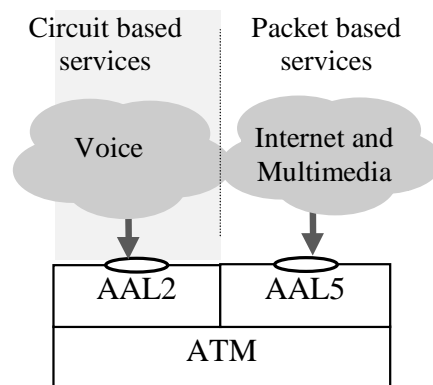

Figure 74

Figure 74 shows the proposed common ATM platform with two AALs on top of it:

AAL2 provides Service Access Points (SAPs) for voice circuits; it allows frames coming from different calls to be multiplexed into the same ATM cells. Such a mechanism is mandatory in order to increase the efficiency in the ATM cells usage as the typical size for radio frames in a TDMA or CDMA radio interface is about one hundred bits, while the ATM payload is 48 bytes.

AAL5 provides SAPs for the IP networking layer and the above applications. The ATM/AAL2 switching is used only for circuits implementation, while IP packets over AAL5 are de-encapsulated at every node in the network to perform a real IP routing. This means that each node where the IP over ATM protocol exists should be connected by semi-permanent ATM links to all nodes it can reach directly; the role of IP networking would be to process the IP layer and determine the correct output port.

Figure 75 shows the proposed network architecture for UMTS. This architecture contains a Core Network part, composed by MSCs and connected to an access network composed by RNC and Node B network elements.

All the nodes in the network use a common transport platform, i.e. use the ATM as the OSI layer 2 protocol in the whole network. The connections between all the nodes are made using ATM links.
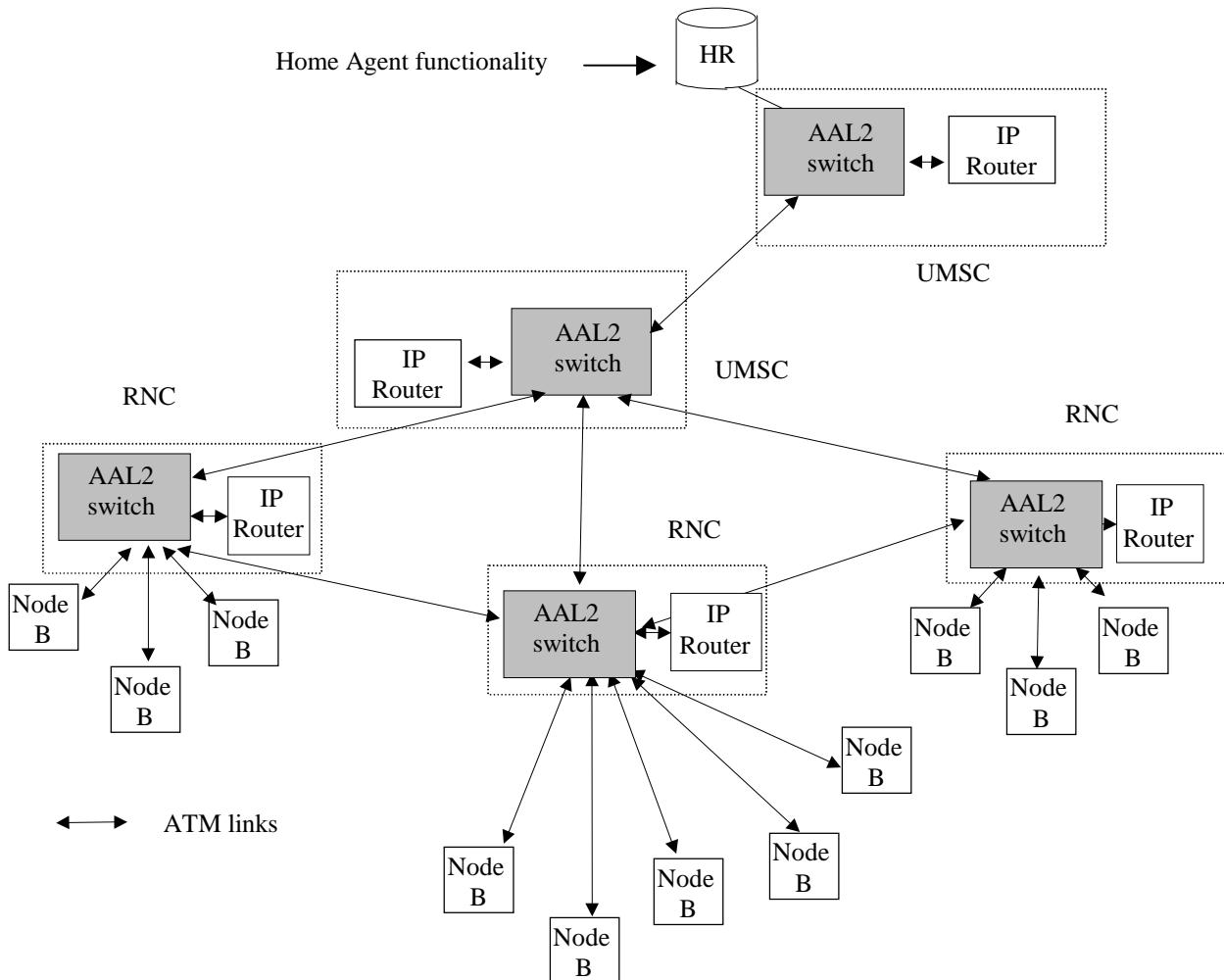

Figure 75

All network aspects are in line with SMG2 assumption concerning Access Network architecture.

The main differences comparing this architecture with a Second Generation System are therefore:

- the transport technology, able to carry both circuit switched and packet switched data flows, and offering an homogeneous data link level within the entire mobile network, unlike the GSM/GPRS network;

- switching and routing functionality at RNC and MSC level

- the presence of IP routers in the network. As said above, one of the characteristics of the proposed architecture is the presence of IP nodes in order to perform the necessary routing functionality related to IP traffic. IP routers could be integrated inside MSC and RNC nodes or even be realised with external devices connected through an ATM interface.

- the links between RNCs.

The Core network part (i.e. the network of UMSCs) would contain call control and mobility management functions, according with functional architecture principles in 23.10. In particular, the Gateway MSC would have the possibility to interrogate the Home Register, this way providing routing information for both an incoming call and an incoming data stream.

We could imagine a Mobility Management similar to GSM (i.e. based on HR and VLR again) for circuit oriented services, while Mobility Management issues for packet transport in the proposed network could be innovative. As an example, the Mobile IP technique could represent a possible solution; in this case the HR would also play the role of Home Agent, keeping trace of current Mobile Terminal position through a dynamic reassignment of its IP routing address, accordingly with its location [ii].

The IP-Router plays its role on the transport plane; it is an IP router with an ATM data link level (OSI layer 2), whose main function is to route the IP datagrams, processing the IP header information concerning their final destination according to its routing table. This table has an entry for each RNC and each MSC attached to it.

The Access Network includes RNCs and Nodes B.

The RNC is the other pure ATM/AAL2 switch of the mobile network. It's identical to the MSC from the transport point of view, meaning that it also manages PVCs and incorporates AAL2/ATM switching capabilities. Unlike the MSC, the RNC does not have call control and mobility management capabilities, according to 23.10.

As seen for the UMSC, the IP functionality at the RNC level is managed by a router attached to the ATM switch. This router is has the capacity of routing packets between different UMSC, the linked RNCs and possibly the Nodes B.

1.3.3.1 Use of ATM PVCs vs ATM SVCs

Some considerations should be done concerning the use of ATM in the proposed architecture.

As it is already stated in SMG2 that ATM + AAL2 is the standard transport technology at least for voice circuits in the UTRAN, it seems that at lest RNC and possibly all ATM nodes in the network would implement AAL2 switching capabilities.

For these reasons it is worth to consider a solution where the use of ATM is limited to the offer of pure Data Link services through Permanent Virtual Circuits, i.e. avoiding the costly use of ATM switching (and Switched Virtual Circuits) in addition to AAL2 switching.

This assumption would lead to an infrastructure where ATM would offer pure point-to-point links between nodes, while AAL2 switching and IP routing would offer networking functionality for voice circuits and IP packets respectively.

Both alternatives seem to be possible, as SMG2 has not taken jet decisions concerning the use of diversity for packet transport, while an extensive use of diversity for circuit oriented traffic and voice in particular is envisaged.

(

1.4. Scenario 4

Scenario 4 UMTS core network based on ATM

The UMTS core network will as evolution dictates re-use of GSM protocols where appropriate. It is likely that ATM will play an important role. The benefits of ATM include statistical multiplexing, variable bandwidth and support for different QoS requirements. In particular support of AAL2 and AAL5 by the UMTS core network will allow simultaneous handling of voice, data and signalling over flexible bearers. The use of an ATM switch fabric will require the use of protocol adaptors for connection to packet and ISDN circuit switched. Figure 8 shows a model of the UMTS core components. No physical implementation should be taken from this model. Indeed the packet handler and IP router can be considered to be similar in functionality to the SGSN and GGSN in GPRS, these could be physically mounted within a 'UMTS MSC' or external.
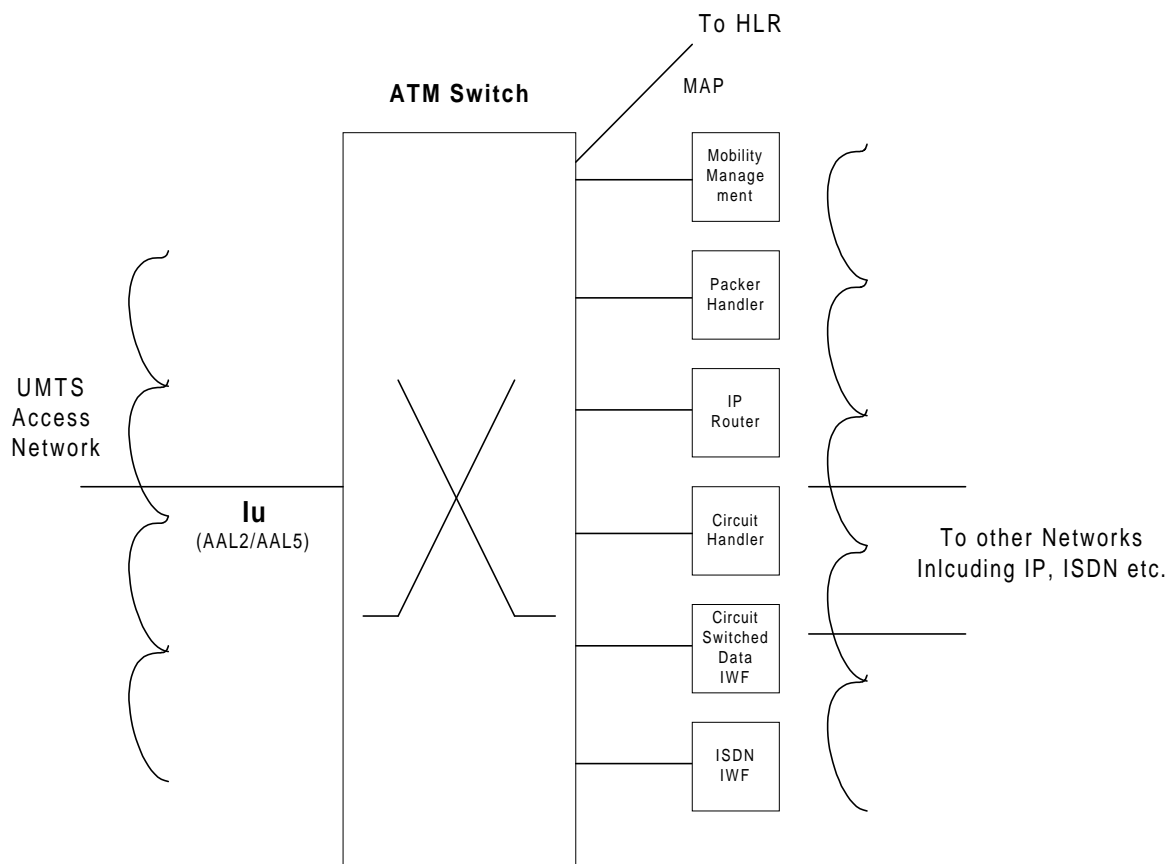
Figure 76 UMTS Core based on ATM

The present regime of attempting to evolve GPRS and GSM simultaneously or even separately could lead to divergent networks. In particular the current scheme leaves mobility handled in two different locations. Possible solutions to this are :

- The Gs interface could be used to try to integrate the mobility for both packet and circuit switched voice call, perhaps allowing a tighter coupling between SGSN and MSCs.

- A new network element UMTS MSC could be created based on both GPRS and MSC.

- Improve the QoS of GPRS such that voice could be handled by GPRS

The first solution has probably the best evolution potential but based on the fact that both GPRS and GSM MSC will eventually change to handle UMTS efficiently, the second solution has credibility as it could be implemented in such a way so as to allow complete backward compatibility with GSM. The third solution can be thought of as the packet

solution paving the way for Voice over IP services. At present there are a number of issues which would need to be solved including QoS, support of supplementary services, Camel etc.

Taking into consideration the present timeline for introduction of UMTS, it is likely that the first stage of the introduction of UMTS into an existing GSM network will be connecting the UTRAN to existing GSM core networks (GPRS is not explicitly shown as no operators at present have deployed GPRS nor will all operators necessary deploy GPRS).

In this initial scenario the UTRAN will probably be limited to the services given by an existing GSM network due to the constraints of the core network but this will depend on the service deployment by operators. But this will enable the operator to have a chance to verify the UTRAN and the third generation air interface using the GSM core as a known reference. In the longer term, evolution of the GSM core is required to realise the potential of the UTRAN. The stage 2 depicts the evolved GSM or UMTS core network

Note: the UMTS core network is also shown here as supporting GSM. Roll out of GSM equipment does not stop due to the introduction of UMTS, hence it may be interesting for an operator faced with three different core network architectures (GPRS,GSM and UMTS) to have the option of one core network. For this to be feasible the protocols and procedures developed for UMTS should take into account backward compatibility with GSM, hence mobility management will be based on GSM map, call control will be based on 04.08 CM and session management concepts from GPRS will be re-used. IE:
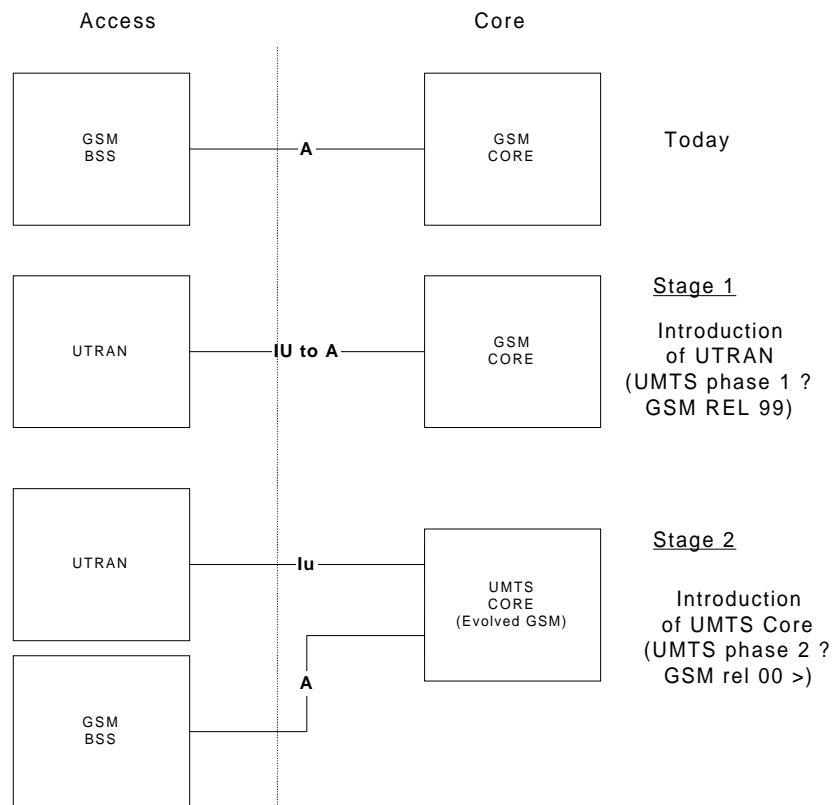
Fig 77 Introduction of UMTS to GSM network

The UMTS MSC must be capable of supporting the UTRAN in an efficient manner, it is therefore likely to use ATM as a transport mechanism. In addition the UMTS MSC must appear as a GPRS node to maintain compatibility. It therefore has the function of QoS control, packet handling and session management. The mobility would be done in such a way such that GPRS MM and GSM MM are integrated.

1.4.1. UMTS Core Physical Architecture

An example of high level physical implementation is shown in Figure 78.

Key points.

- Session management extended to cover all call types

- Integrated Mobility for Voice and Packet

- Re-use or extensions to existing GSM protocols

- ATM transport for UMTS

- Optional support for GSM and GPRS basestations

- QoS management plays a prominent role

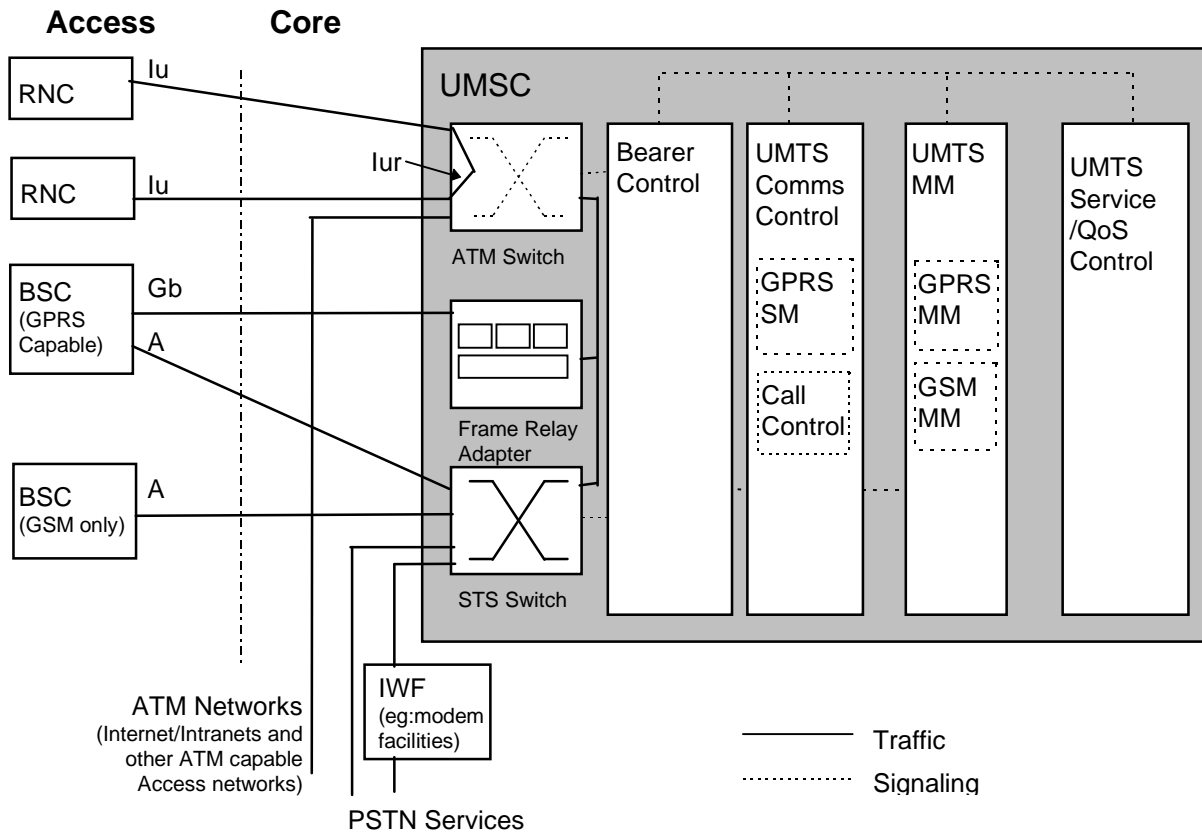- Bearer control separated from session and call control

Figure 78 Example of an UMTS MSC (Integrated Solution)

Note: This is one possible implementation and should not preclude others, it is possible that the same concepts could be followed for the implementation as shown in Scenario 4 but tight co-ordination would probably be required on the Gs interface between MSC and SGSN to co-ordinate the mobility issues.

1.4.2 Protocol Architecture

1.4.2.1 Signalling plane

Figure 79 shows the protocol stack between the MS and UMSC for the signalling plane.
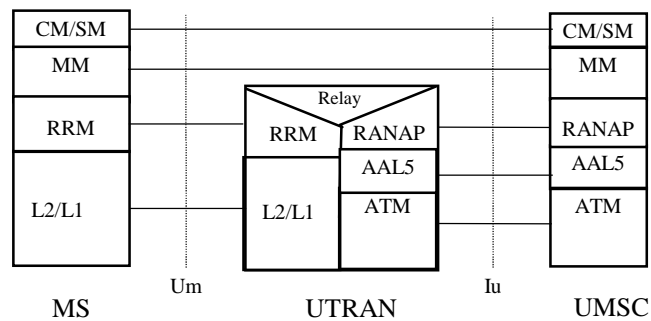
Figure 79: Signalling plane MS-UMSC

Legend:

RRM: Radio Resource Management handles the radio resource allocation.

LAC: Logical Access Control provides a reliable logical link between the MS and UTRAN

RANAP: Radio Access Network Adaptation Protocol

The above layers are as defined by SMG2 and is only mentioned here for reference.

AAL5: ATM Adaptation Layer 5

MM: Mobility Management layer

CM: Communication manager (for circuit switch)

SM: Session Manager (for packet switch)

A common ATM based interface is used over the Iu reference point. This interface will carry circuit and packet switched signalling as well as user data for both modes.

The MM layer will be common for both packet and circuit switched services, including a common VLR. Part of the CM and SM is also expected to be common.

1.4.2.2 Transmission Plane

Figure 80 shows the protocol stack between the MS and UMSC for the transmission plane, using an evolved GPRS architecture for UMTS.
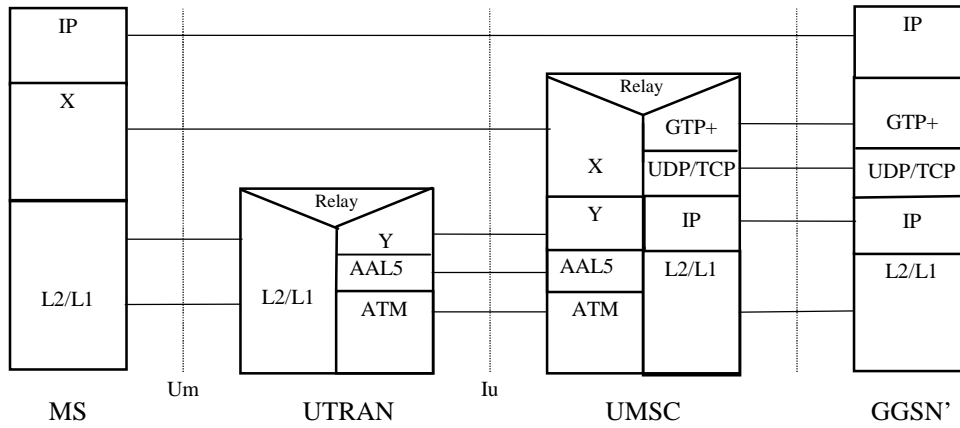
(

Figure 80 User plane for an evolved GPRS

The interconnection between the UMSC and GGSN' (which is evolved GGSN) will be an evolved Gn interface based on an evolved GTP (called GTP+).

Much of the functionality provided by the SNDCP and LLC GPRS layers is expected to be provided by the UTRAN and ATM. Hence, layer X is instead a place holder for some remaining functionality that might be required to be implemented at the UMSC. Similarly, layer Y is a place holder for any BSSGP like functionality which may be required.

The requirement and functionality of both layers X and Y are for further study.

CS traffic will use ATM and AAL2 over the UTRAN and Iu interface.

1.4.2.3 Support of Mobile IP

Figure 81 shows the protocol stack between the MS and UMSC for support of Mobile IP within UMTS using the UMSC.

The Foreign Agent (FA) functionality can reside within the UMSC. The MS will register the care of address with the HA. This registration message is carried transparently in the user plane between the MS and the UMSC. Within the signalling plane, IP interacts with the SM to set up sessions with the required QoS.
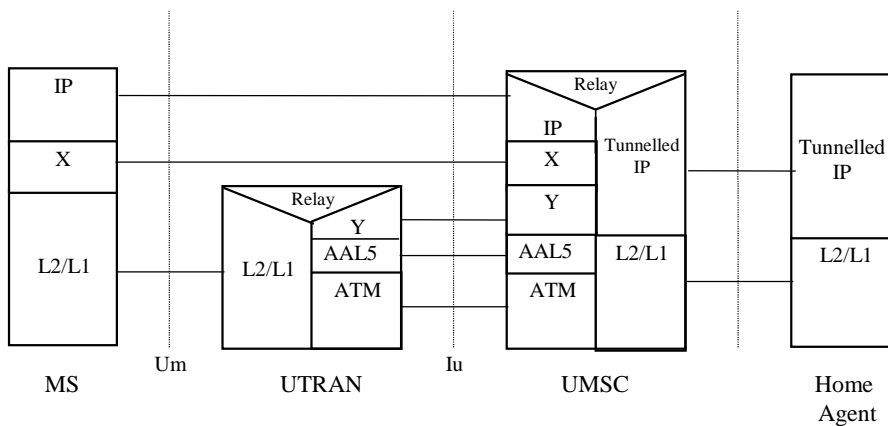

Figure 81 User plane for support of Mobile IP

1.4.3. Common Location register (U-VLR)

A common location register (called U-VLR here) that holds one location information for both packet and circuit switched modes while the MS is registered with the U-VLR. The U-VLR can be standalone unit or can be integrated with a common UMTS MSC (handling both packet and circuit modes). MAP protocols may be used if the U-VLR is remotely connected to the UMSC. The U-VLR is also connected to the HLR using MAP interface. Location updates and attach messages from the MS are directed to the U-VLR by the UMSC . Paging messages are sent out by the U-VLR to the MS via the UMSC .

The HLR is updated by the U-VLR when the user registers with the U-VLR. The HLR should support storage of the single serving U-VLR address of the MS attached for packet and circuit switched services. It will still be required to store the VLR and SGSN addresses as an alternative when the MS is registered in networks that might have separate VLR and SGSN. The U-VLR also holds a local copy of the subscriber profile. It also handles implicit detach timers, authentication and TMSI reallocation.

1.4.4 Session and QoS management

1.4.4.1 Session Management

The basic concepts behind the combined session management are to encompass both GSM and GPRS call / session handling into a common framework which will be carried over a common transport.
A user shall initiate a service request, which shall identify the type of service required. A request for CS service shall instantiate an CS call model within the MS and core network (CN). A request for a PS service shall instantiate an PS session model within the MS and the CN. The CS call model will be wholly based on the current GSM CM model. The PS session model shall be an evolution of the GPRS session management model. This means that CS services and PS services may have their own CM models.

As a possible further evolution, the CS and PS models may be combined to provide a totally unified Communication Control model. This work would be for future study.

1.4.4.2 QoS Management

The schemes shown below are illustrative examples of how QoS may be achieved. They do not preclude other methods of achieving QoS within sessions.

CS Services

A request for a CS service will have a fixed QoS associated with the request, and must be stated explicitly within the initial set up message.

IP without explicit IP based QoS signalling

The UMTS session management procedure for IP traffic without explicit IP based QoS signalling is illustrated in Figure 82. Each step is explained in the following list.
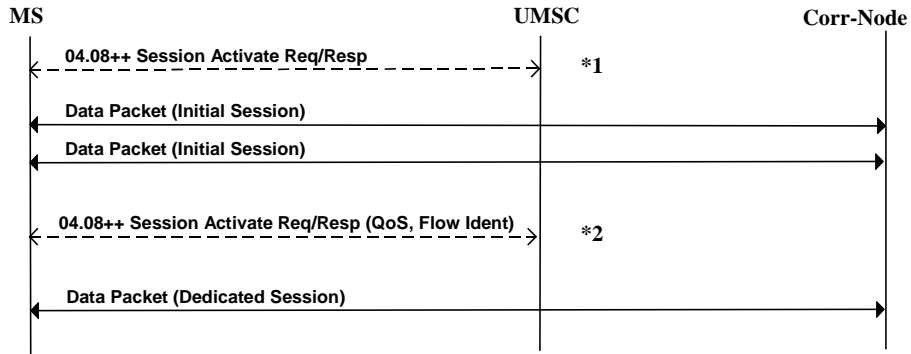
Figure 82

a) The user shall activate a data session. At this point, the user may start to transmit and receive data.

b) If the UMSC recognises a type of flow of traffic, the user profile shall be checked, and a request will be sent to the user to setup a QoS session dependent upon what the user has subscribed to for the type of traffic flow identified. If the user decides to activate the session, all traffic with the identified flow will use the dedicated session.
A possible option would be to modify the existing session, as opposed to creating a new session.

IP with explicit IP based QoS signalling

The UMTS session management procedure for IP QoS signalling is illustrated in figure 2. The QoS signalling procedure illustrated is for RSVP Mobile Originated (MO), however as the UMSC is acting at a user level IP, any other IP QoS schemes can easily be adapted. Each step is explained in the following list.
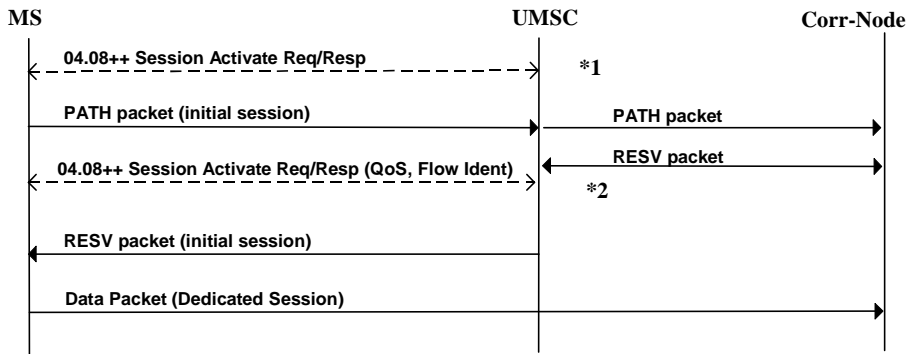
Figure 83

a) The user shall activate a data session. At this point the user may start to transmit and receive data

b) The UMSC shall (as in current IP routers) process the RESV packet, and request the user to establish a session based on the QoS requirements contained within the RESV packet. If the user decides to activate the session, all traffic with the identified flow will use the dedicated session.
A possible option would be to modify the existing session, as opposed to creating a new session.

1.6 Scenario 6

3G GSN for IP CN - the IGSN (Internet GPRS Support Node)

The GPRS network must evolve to efficiently support present and future IP services within UMTS. Operators who offer IP services to UMTS users, which also includes fixed users, will benefit from being able to coordinate network resources as well as equipment for mobile and fixed IP based networks, i.e. minimizing the number of different types of networks. By combining the SGSN and GGSN into one node, the Internet GPRS Support Node (IGSN), and adapting it to utilize MobileIP for handling inter IGSN mobility, a standard IP network can operate as a UMTS CN.

In such a scenario, most of the functions, presently standardized to be handled by the SGSN and its associated databases VLR, HLR, AuC, etc will be crucial for complementing MobileIP. These functions include authorisation of users/terminals, handling of subscriber data, handling and distribution of encryption keys, creation of charging detailed records (CDR) etc.

The example below will clarify the cooperation between GSM/GPRS and Mobile IP. This example assumes IPv6, but the cooperation principles are the same for IPv4.

First, the case where the terminal stays within its home IP network will be described. This is illustrated in figure 27.

- The mobile terminal arrives at a new UTRAN and listens to the radio broadcast messages, which contain information about radio parameters, network and cell identity, etc. as well as information about available core networks, service providers, service capabilities etc.

- The mobile terminal sends a registration request including parameters such as identity, desired service provider etc.

- The UTRAN forwards the registration request to the IGSN, which processes it:

    - The IGSN contacts the HLR of the mobile terminal to collect data to perform an authentication procedure.

    - Once the terminal is authenticated and found to be allowed in the present UTRAN, all information over the radio interface can be encrypted. Encryption keys are obtained from the HLR.

- Now, the terminal can start communicating over the IP layer. The terminal listens to router advertisement messages and solicits the nearest DHCP (Dynamic Host Configuration Protocol) server to obtain configuration parameters and a Mobile IP care-of-address. The HLR records should be enhanced to include the current care-of address of the mobile terminal.

- The mobile terminal will then contact its home agent (HA) to register its new care-of address according to standard MobileIP.

- The HA has to accept or reject the registration of a care-of address. Before making a decision, the home agent could contact the HLR (via a new interface, Gh) to obtain information that this terminal is properly registered. In addition, the keys needed for using the IPsec authentication header and/or the encapsulation security payload between the terminal and the HA could be obtained from the HLR. The mobile terminal can derive its keys from information on its USIM in the same way as in the GSM system.

- While the terminal is connected and transmits data, charging detailed records are produced by the IGSN. Systems for billing and customer handling, already in operation for GSM and GPRS, may be used also for UMTS.
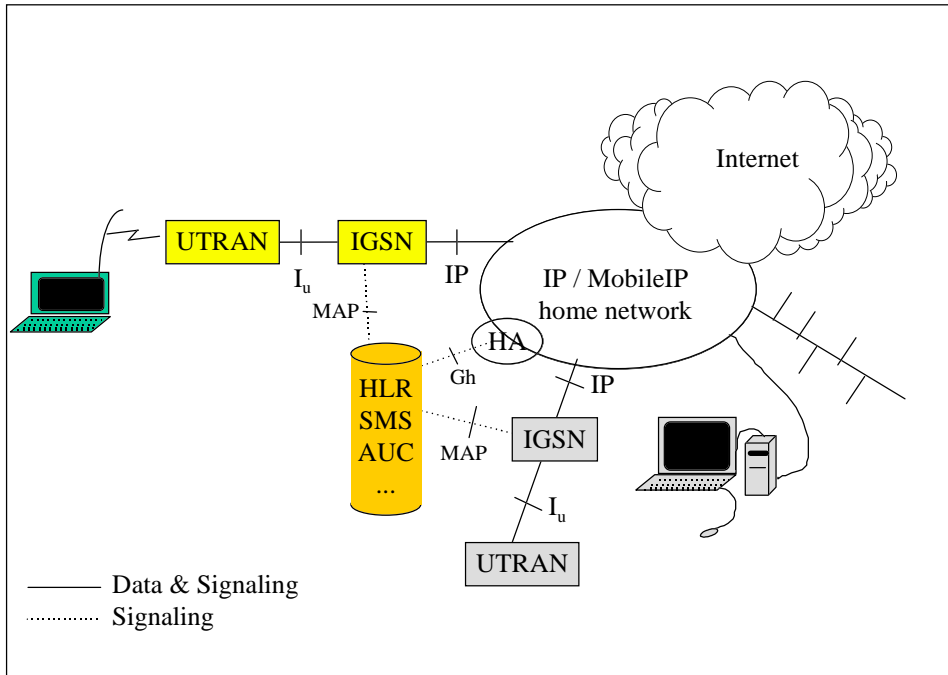
(

Figure 84. Scenario with IGSN (the combined SGSN and GGSN), and Mobile IP support for inter IGSN mobility. Gh is a new interface between the HA and the HLR.

The case where the mobile terminal roams into a foreign network is similar, the only difference being that the visited IGSN contacts the HLR in the terminal's home network, either via the international SS7 network or by tunneling the MAP protocol messages through the Internet or an inter PLMN IP network. The mobile terminal registers with its home agent as in the case above.
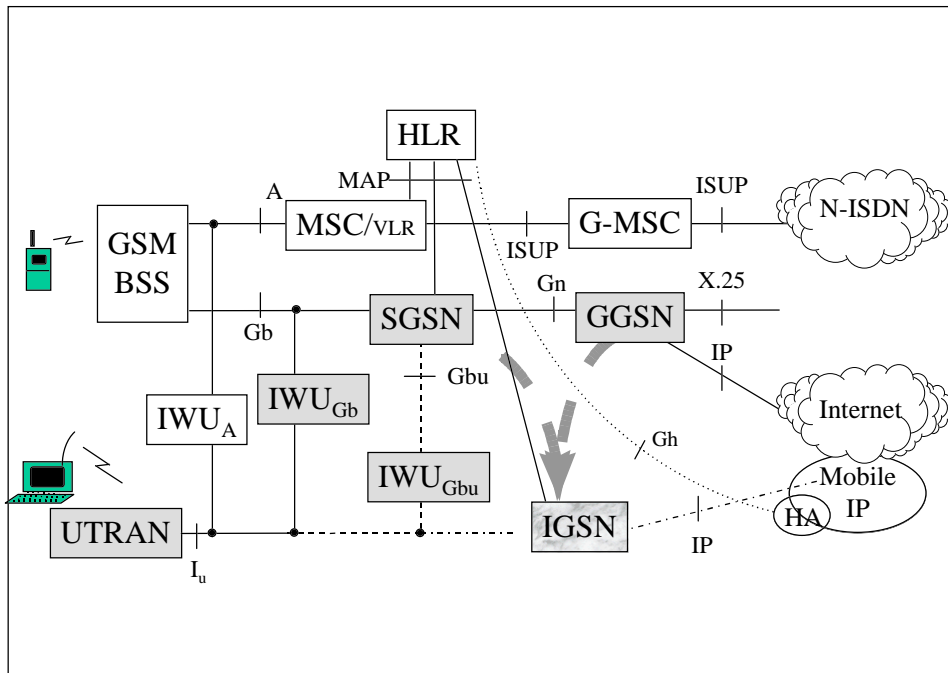

Figure 85. Evolution scenario for UMTS. The SGSN and GGSN are combined into one node, the IGSN.

The evolution scenario is depicted in Figure 85, where the SGSN and GGSN are combined into one node, the IGSN. Depending on how far the adaptation of the SGSN to the Iu interface has progressed at the time of introduction of the described architecture, the IWU_{Gb} or IWU_{Gbu} (taken from an earlier scenario) may be needed between the IGSN and the UTRAN.

1.6.1 Mobility Management

Mobile IP enables users to connect to different IP subnetworks, while always using their permanent or long-term IP address. The protocol designed to support macro mobility, i.e. mobility between different subnetworks. Mobility within the subnetworks, e.g. handovers between base stations, is expected to be handled by the underlying network. According the standards [1], HO between subnetworks should not occur more often than once per second.

While the mobile terminal is located at its home subnetwork, it operates like a regular terminal, i.e. no MobileIP signalling occurs. When the mobile terminal arrives in a foreign subnetwork, it obtains a temporary address, a care-of address, which it registers with its home agent (HA), a node in its home network. When datagrams arrive in the home network, the HA intercepts them and tunnels them to the current care-of address.

In IPv4, the mobile terminal has to register with the Foreign Agent (FA), a router in the foreign network, which provides routing services to the mobile node while registered. The care-of address in the foreign network can either be determined from a FA's advertisements (a foreign agent care-of address), or by some external assignment mechanism such as DHCP [2] (a co-located care-of address). In the former case, the IPtunnel from the HA is terminated in the FA and in the latter case in the terminal.

Extensions to the base Mobile IP protocol have been defined [3] to allow for optimization of datagram routing from a correspondent node to a mobile node. Without Route Optimization, all datagrams destined to a mobile node are routed through that mobile node's home agent, which then tunnels each datagram to the mobile node's current location. The extensions provide a means for correspondent nodes to cache the binding of a mobile node and to then tunnel their own datagrams for the mobile node directly to that location, bypassing the route for each datagram through the mobile node's HA.

In IPv6 [4], the FA has been eliminated and the terminal will always use a co-located care-of address. It is mandatory for all nodes to support caching of bindings for mobile nodes, which means that routing will always be optimized, unless the terminal chooses to communicate via its HA. Contrary to GPRS, optimized routing is inherently supported, also between two mobile nodes within one PLMN.

In the case of UMTS, the FA should preferably be located in or in conjunction with the IGSN, since each UTRAN or access network is seen as an IP subnetwork.

The location of the HA is more flexible. The options, which does not exclude each other within one PLMN, are:

- In a virtual subnetwork within the UMTS backbone. With such a solution, the mobile terminal will always use a foreign subnetwork.

- In conjunction with the IGSN, i.e. the terminal has a real home subnetwork. This solution lowers the signaling load for users, who mostly stay within one UTRAN/BRAN/etc., especially in the case of vending mashines etc.

- In a LAN etc. exterior to the PLMN, which would correspond to the case in GPRS, where GGSN's are placed in conjunctions with private LAN's.

Compared to GSM and GPRS, the mobile terminal performs more mobility management signaling in MobileIP when it is located in a foreign subnetwork. It has to be ensured that this does not put too much of a strain on the radio resources. On the other hand, it facilitates the deployment of optimized routing and the compatibility with fixed networks.

References:

[1] C.Perkins: "IP Mobility Support", IETF RFC 2002, October 1996,

     ftp://ftp.isi.edu/in-notes/rfc2002.txt

[2] R.Droms: "Dynamic Host Configuration Protocol", RFC 2131, March 1997.

     http://src.doc.ic.ac.uk/computing/internet/rfc/rfc2131.txt

[3] C.Perkins, D.B.Johnson: "Route Optimization in Mobile IP", Internet draft, November 1997.

http://www.ietf.org/internet-drafts/draft-ietf-mobileip-optim-07.txt

[4] D.B.Johnson, C. Perkins: "Mobility Support in IPv6", Internet draft, August 1998.

http://www.ietf.org/internet-drafts/draft-ietf-mobileip-ipv6-06.txt

1.6.2 Session-management and QoS support for IP services

For *mobile-initiated sessions* (refer to Figure 86), RSVP PATH packets are sent from MS to the IGSN in order to convey the characterisation parameters for the IP flow that MS is going to generate. The message is relayed by the IGSN to the IP Corresponding-Node, which then replies with a RESV message, conveying QoS requirements for that flow. The information is processed by the SC element in the IGSN, in order to establish a session based on the QoS requirements contained in the RESV message. Session estabilishment includes bearer setup between the MS and the IGSN. After the estabilishment of the session, the RESV message is relayed to the MS using the dedicated resources. Thus, receiving the RESV message, the MS creates a mapping between the dedicated resources and the IP flow belonging to that particular session. From now on, communication from the MS to the Corresponding-Node through the dedicated resources is possible.
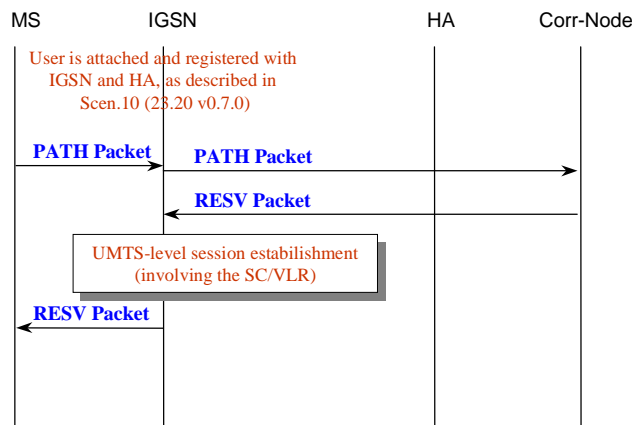

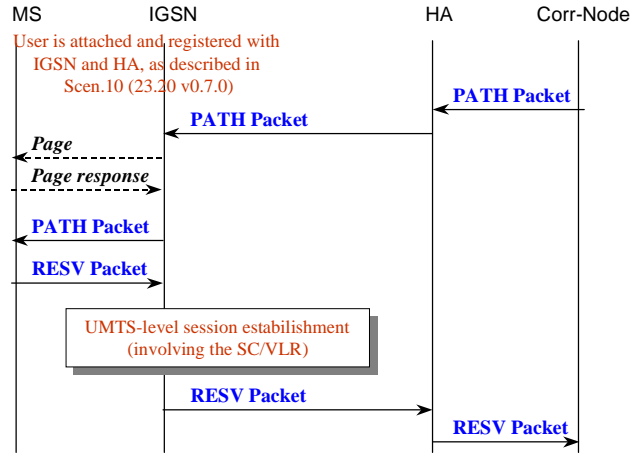Figure 86. Session management and QoS: mobile-initiated sessions.

Figure 87. Session management and QoS: mobile-terminated sessions.

For ***mobile-terminated sessions*** (refer to Figure 87), RSVP PATH packets are sent through the HA from the Corresponding-Node to the IGSN in order to convey the characterisation parameters for the IP flow that the Corresponding-Node is going to generate. After the paging procedure, the message is relayed by the IGSN to the MS, which then replies with a RESV message, conveying QoS requirements for that flow. The information is processed by the SC element in the IGSN, in order to estabilish a session based on the QoS requirements contained in the RESV message. Session estabilishment includes bearer setup between the MS and the IGSN. The IGSN creates a mapping between the dedicated resources and the IP flow belonging to that particular session. After the establishment of the session, the RESV message is relayed to the Corresponding-Node, and communication from the Corresponding-Node to the MS is possible.

The possibility to transmit IP-level signalling messages (e.g. PATH and RESV messages) on the air interface via the FACH-RACH (prior to the estabilishment of a session) should be studied.

Admission-control in the Internet and in the IP/Mobile-IP home network takes place following the mechanisms defined for IP networks.

In addition, the use of RSVP between the MS, the IGSN and the Corresponding-Node does not preclude the use of mechanisms for providing IP-level QoS in the IP-based home network alternative to Integrated-Services (e.g. Differentiated-Services).

1.6.3 Implementation scenarios

The IGSN, and the SC/VLR, can be implemented either as a stand-alone node, integrated in an MSC, or co-located in an RNC/FSU. In addition, as a future evolution, it is possible to think about an integrated SC/VLR for both Packet and Circuit Switched services.

1.7 Scenario 7

Service Migration Scenario

The current footprint of the Internet/Intranets together with the strong momentum in the development and deployment of IP technology constitute undisputed proofs of a new era in not only services/applications provisioning but also networking and communication. With an exponential growth, driven by existing and new applications, the traffic carried by the different IP networks (Internet/Intranets) is expected to exceed by far the traffic carried by any other network technology within a near future.

Having been used so far to mostly carry best effort type of traffic, real time critical applications such as voice and video are now beginning to appear on the Internet/Intranets. With the introduction of new network capabilities in different parts of the IP standards and the network implementations this process will further accelerate. In a longer term perspective all this is expected to be followed by a migration of services from PSTN/ISDN into the IP world. Such a service migration is a logical outcome when considering that 'voice' eventually will represent just a fraction of the total amount of transferred application data (number of bits) and consequently will not justify a network of its own in the long run.

Starting in the corporate and public sectors, where 'Voice over IP' and similar products for commercial use already exist, the network transformation process described above will eventually also influence the mobile community and to a considerable extent impact the rules and conditions for UMTS. This chapter describes one possible long term evolution scenario for UMTS, based on a service migration from the UMTS PSTN/ISDN domain into an enhanced IP based common packet core network managing all UMTS services/applications.

1.7.1 Basic Assumptions and Driving Forces

The scenario shall be seen as a result of certain basic assumptions/postulates regarding various technical and commercial issues, driving forces on the infocom market etc. Important assumptions/postulates are:

- Multimedia is about applications. Applications are created by the market, beyond the control of the mobile community standardization.

- The applications are the prime driver of the network evolution.

- The multimedia revolution will happen primarily in the IP world, not in the PSTN/ISDN ditto (B-ISDN end-to-end still not moving)

- There is currently nothing on the horizon challenging IP as the dominant network technology. The position of IP will further strengthen over time. Subject to a very strong development IP will eventually become a true multi services network technology.

- In view of the momentum in IP technology deployment significant cost reductions (network components) should be possible compared to alternative technologies.

- The ties between the PSTN/ISDN paradigm and the IP paradigm are very weak. There are currently no visible forces strong enough to successfully merge the two.

1.7.2   Fundamental Principles

The scenario rests on a number of principles, the most fundamental ones being:

- The scenario reflects an application driven evolution, rather than a network technology driven ditto, in order to meet the prime target of UMTS to efficiently support the existing and new generation of applications.

- The core network is optimised to the dominant applications which it is supposed to carry.

- Services and applications are migrated from the UMTS PSTN/ISDN domain into an enhanced IP based packet domain as illustrated in Figure 88. This is a fundamentally different approach to a common core network architecture compared to the method of integrating the UMTS circuit and packet domains.

- The core network technology is aligned with that of the principal networks (Internet/Intranets) to which the core network should interconnect.

- The choice of transport technology (layer 1/2) is independent of the network technology (layer 3).

- The scenario capitalises on a number of existing/planned core network capabilities/functions within GPRS, thus limiting the needs for new standards, product development and network upgrades. Examples of currently planned/discussed GPRS enhancements:
  - Enhanced QoS support
  - Support for point-to-multipoint
  - Separation of bearer establishment from the ISP service environment setup
  - Mobile IP interworking
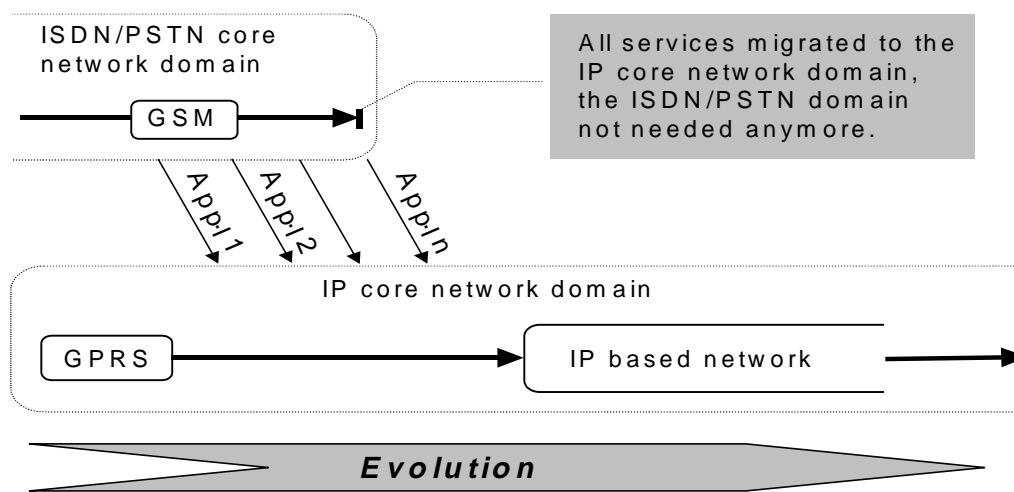 - Charging features (pre-paid, advice of charge, hot billing)

Figure 88. The principles of service migration from the ISDN/PSTN domain into an enhanced IP based packet domain in UMTS.

1.7.3 Technical Characteristics

The UMTS network model and core network functional distribution are outlined in Figure 89 and Figure 90. From a technical point of view the functional distribution is characterised by:

- One core network only, simplifying core network management.

- Core network based on main stream IP technologies.

- Client/server oriented architecture in line with standard IP solutions (see figure 31).

- Use of 'telephony' servers/interworking units for support of PSTN/ISDN specific services (voice, fax, modem, UDI etc).

- Use of proxy technologies for efficient data transport over the air interface.

- Enhanced QoS support in order to accommodate all real time critical applications.

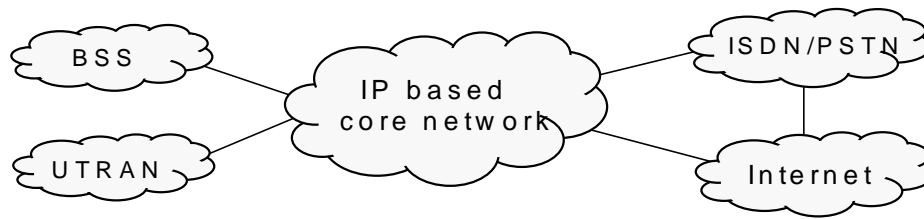- High capacity core network based on e.g. terabit router technologies.
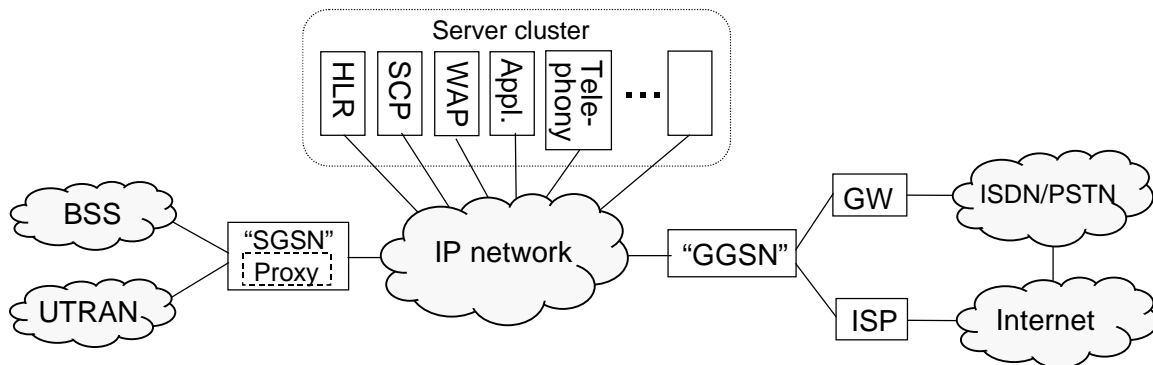
Figure 89. UMTS network model (simplified)

Figure 90. Principles of the UMTS core network functional distribution.

Note: Only UTRAN and BSS are shown in Figure 89 and Figure 90 . This does not exclude the possibility to connect the core network to other types of radio access networks, e.g. BRAN.

1.7.4 Opportunities

The scenario offers a number of opportunities such as:

- Capitalise on the comprehensive and rapid development within the IP world (applications, network architecture and technologies).

- Reuse of several of the existing functions and network capabilities of GPRS.

- Reasonably simple migration from today's GSM/GPRS architecture. Migration of individual PLMNs can be done independently of the rest of UMTS.

- Transport technology independence, allowing:
  - Transport arrangements to be tailored to each operators businesses and needs.
  - New transport technologies to be deployed as they emerge.

- Internetworking for e.g. roaming by means of PLMN external networks and standards.

1.7.5 Related Actions

Further investigations of this scenario is needed in the following areas among others:

- QoS (requirements, traffic management, mapping of QoS between different network segments/layers).

- Functional enhancements in the core network elements in order to support all relevant applications.

1.8 Scenario 8

There still exist two logically separate network elements as in the other scenarios, 3G MSC and 3G SGSN which provide interworking with circuit switched and packet routed networks, respectively. Both can be evolved smoothly and individually starting with a 2nd generation MSC or SGSN by adding UMTS specific functionality to either side according to market needs. This, however, doesn't preclude that a common transport network (e. g. ATM) is used for both types of networks. The interconnection between Iu interface and core network is achieved by a common IWU which is connected to both entities. It distributes originating call/connection requests to either side. As well it co-ordinates terminating traffic.
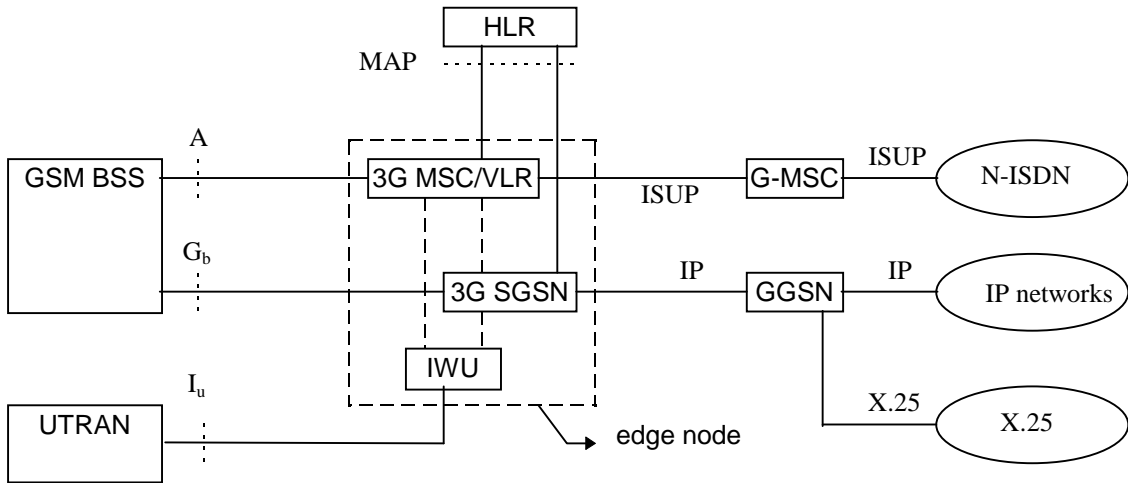
Figure 91..

Evolution can lead to an even more integrated UMTS edge node:

Figure 92.

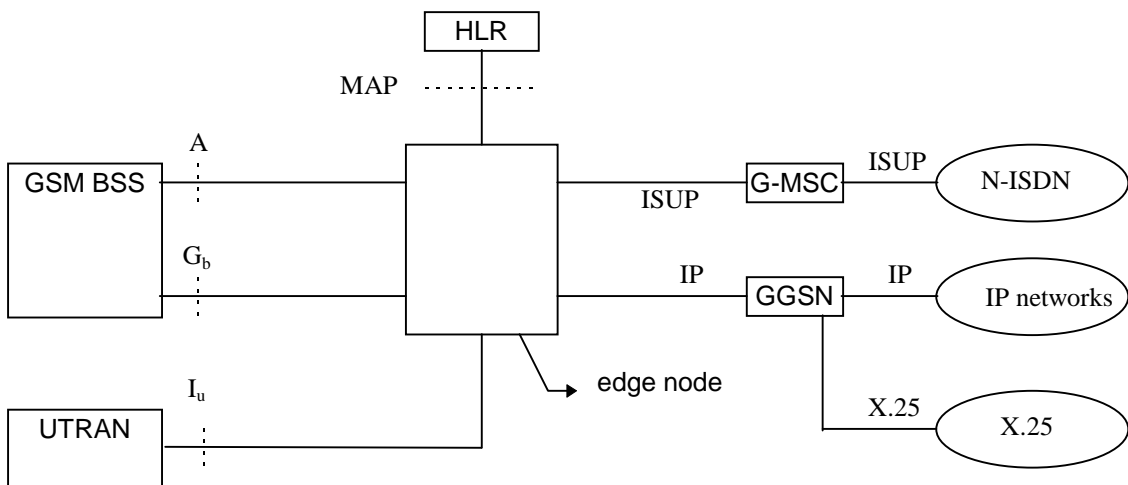## 1.8.1. Signalling and Mobility Management

Unlike other scenarios there exists already in UMTS phase 1 only one instance of mobility management for a terminal/user on the I_u interface. All signalling is based on one signalling resource per terminal/user. This means that on this interface change of location (e. g. location update, GSM-like attach/detach, handover, ...) is reported only once, and

there exists only one incarnation of authentication and ciphering key per user at a time. As well mobility management in the CN would be instantiated only once for a user who has camped on a UTRAN. This requires enhanced coordination between MSC/VLR and SGSN in order to access this mobility management function.

This scenario avoids all the complexities on the I_u-interface which relate to the twofold nature of the core network.

1.8.2. Call/connection Management

On the I_u interface multiple calls/connections can be established for one terminal. Each connection relates to either 3G MSC/VLR or 3G SGSN.

1.8.3. Proposed protocol stack

The proposed protocol stack comprises three parts:

- User Plane

- Transport Signalling for the establishment of dedicated channels

- Control Plane

At the bottom there is ATM over an appropriate physical layer.

The user plane comprises AAL1 channels for circuit switching and multiplexing of packets over AAL5. The details of the multiplexing layer are for further study. Use of AAL2 needs to be clarified in conjunction with the TRAU location.

In order to establish dedicated ATM-channels on the Iu interface a minimum set of B-ISUP is used. It might be possible to use another protocol for that purpose. This needs to be clarified together with the ATM adaptation layers.

Call/connection management and mobility management in the control plane are intended to be very close to the existing CM and MM of GSM. They belong to the non-access stratum.
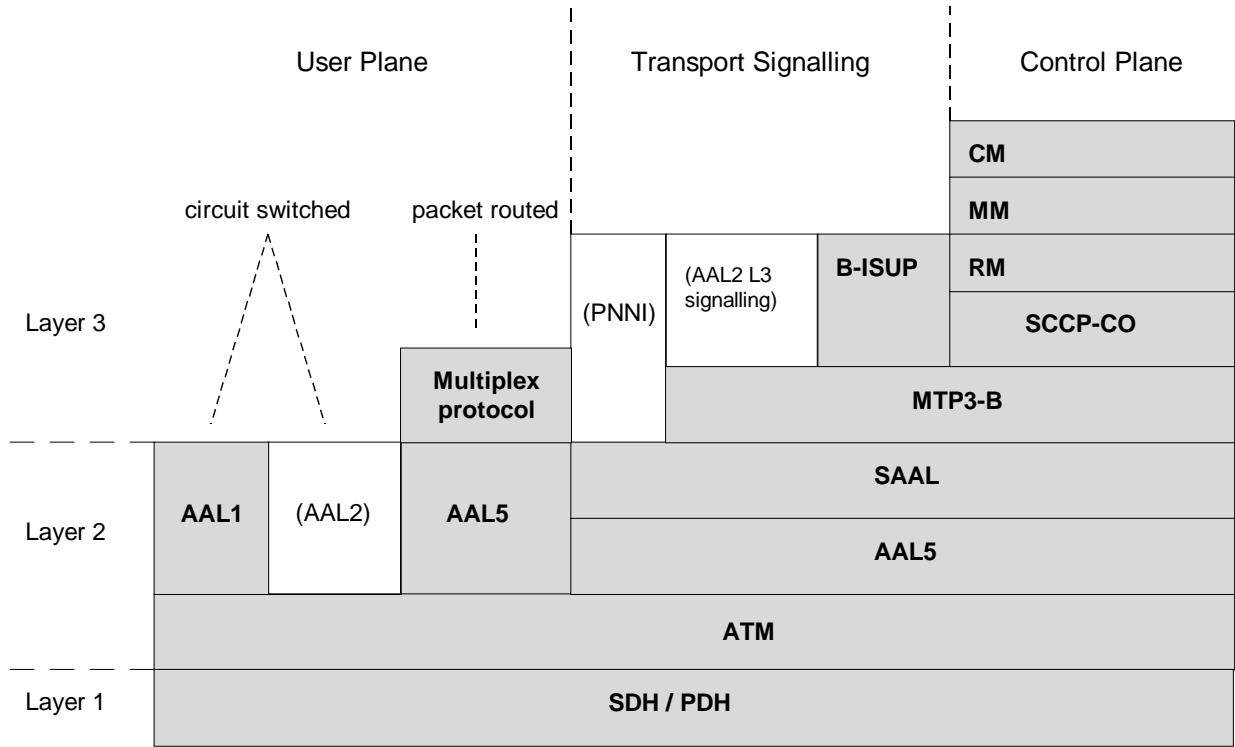
(): Optional Implementation

Figure 93.

1.9 Scenario 9

UMTS Phase 1 Reference Model

UMTS strives to enhance the bit rates of GSM in both, the circuit switched and the packet switched environments. The UMTS system shall comply to the Phase 1 Capabilities, currently under development. This document is focused on a possible target network architecture. It is believed that due to partial deployment of ATM´s technology, it is better to introduce this technology in the Access Network. The Core Network shall follow, depending on country-specific deployment.

This document takes some assumptions as a framework to build upon for UMTS Phase 1:

1) The Iu interface is intended to embed, both the Circuit Switched and the Packet Switched protocol stacks for the corresponding traffic.

2) Mobility Management data are exclusively managed by the Core Network.

3) Subscription data are managed by the Core Network.

4) UMTS shall provide bearer services.

5) No new Teleservices shall be defined, except for those already supported in the circuit switched part of GSM phase 2+.

The Core Network shall have a new entity called a UMTS node. This node shall be composed of circuit and a packet switched parts. Reasons to evolve the UMTS node in the Core Network, as opposed to in the Access Network are the additional functionality needed for call control and mobility management. Take for instance in mobile terminating calls, where subscriber location information is easier to obtain as close as possible to the fixed network boundary; i.e., in the HLR database, as opposed to leave this decision until the Access Network is reached; e.g., in the RNC.

The integration of a UMTS node in the Core Network connected to the UTRAN provides the following advantages, as depicted in Figure 94:

Reuse of the following switching elements:

(G)MSC

GGSN

Further utilisation of the following GSM databases:

HLR

SCP

Reuse of the GSM (circuit switched) and GPRS backbone network.

Same interworking towards the ISDN/PSTN and Packet Data Networks as currently done from the GSM (G)MSC and GGSN.

Unified mobility management in the Core Network for packet and circuit switched user traffic.

The Scenario in Figure 94, also enables the decoupling at the logical network layer and the underlying physical subnetworks within the Core Network.
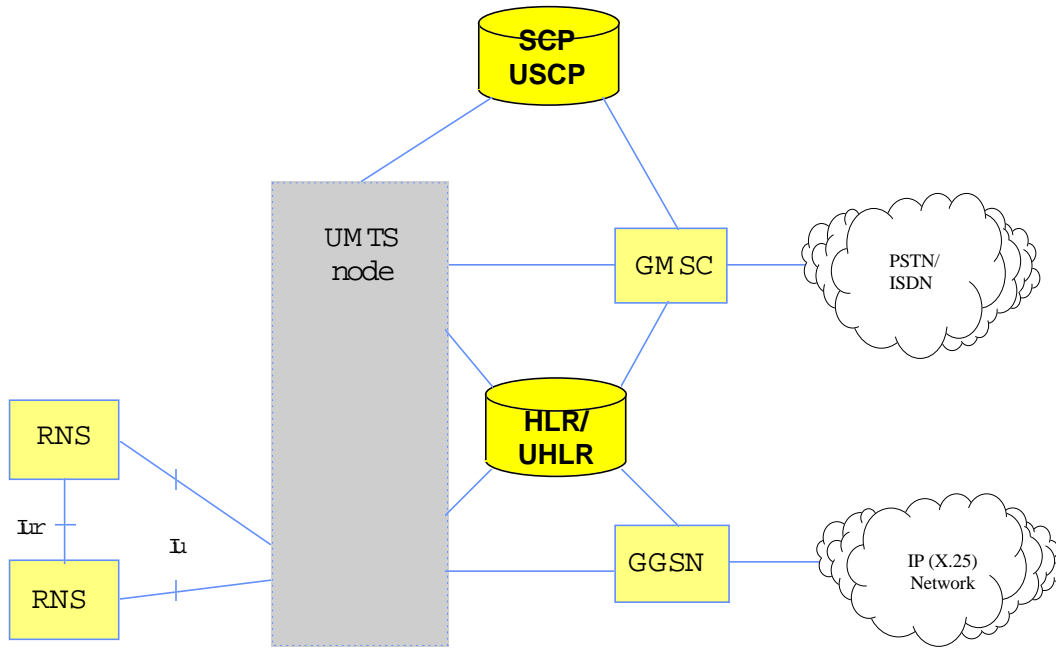
Figure 94 UMTS Reference Model

This scenario also assumes that even in the long term the two existing technology paradigms ISDN/PSTN and IP are valid.

1.9.1 Iu Interface - Transmission Planes

The UMTS node in the Core Network contains two transmission stacks for the packet switched and the circuit switched parts. The Iu interface embeds these protocol stacks as shown in Figure 95.
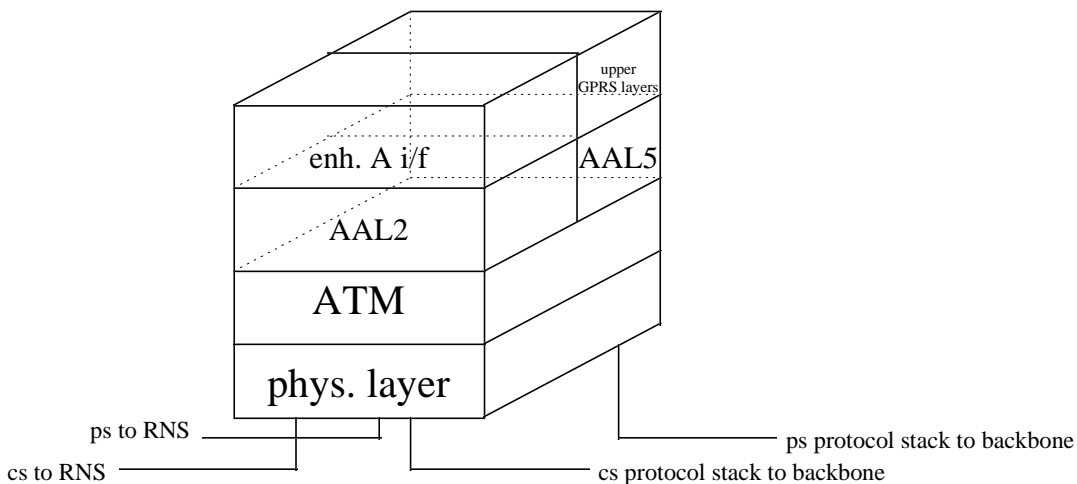
Figure 95. Iu Interface - Transmission Stacks for the Circuit and the Packet Switched Parts.

Figure 95, packet switched (ps) stack part, shows that in principle, and to allow reuse of the GPRS stacks for signalling and traffic, the current GPRS stack lower layers might be replaced from Frame Relay to ATM/AALx transport technology.

The circuit switched (cs) part of the stack shows how the Iu interface may use an enhanced A interface crafted for UMTS usage.

The QoS requirements need to be enhanced with additional requirements as defined by SMG1.

Figure 96 depicts in more detail the transmission plane from the MS to the GGSN via the UMTS node.
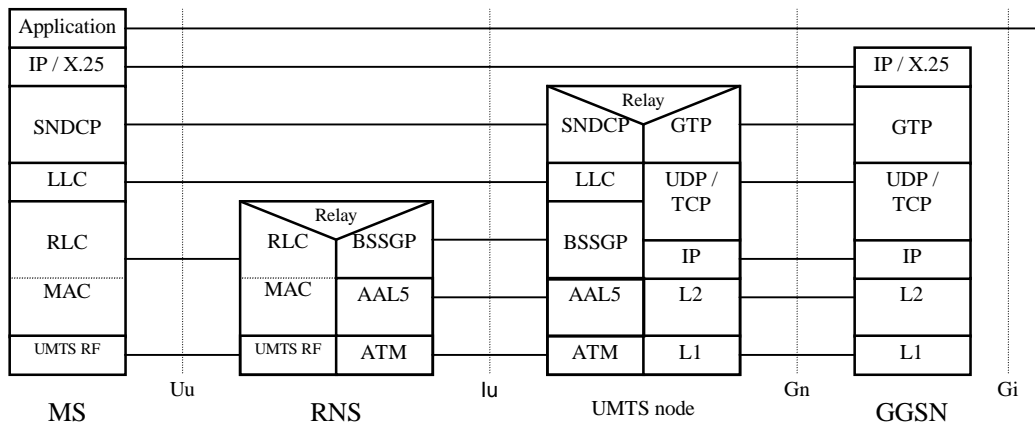

Figure 96. UMTS Node Transmission Plane Stacks.

1.9.2 Opportunities

The approach shown in this Unified UMTS Node scenario in the Core Network provides the following advantages:

Optimisation of current ISDN-type and IP-type services.

Multimedia support by mainstream solutions for ISDN-world (H.320, H.323) and for the IP-world.

UMTS and GSM circuit switched/GPRS will mainly be based on developed ISDN standards and still evolving IP-standards.

1.9.3 Disadvantages

Areas in this approach that need to be studied:

The UMTS Node may be implemented as a single switch or as a two separate components, one managing the circuit switched part and another the packet switched part. Further study is needed to identify the nature of the „internal" or „external" interface communicating the integrated or separate components respectively, for both signalling and traffic.

1.9.4 Complementary Functionality (optional) to the UMTS Node

In addition to the Iu interface, the UMTS Node may support the A and Gb interfaces. This provides operators the opportunity to continue using all already, in large amounts, deployed GSM BSSes. The following Figure 4, shows this enhanced UMTS Node scenario.

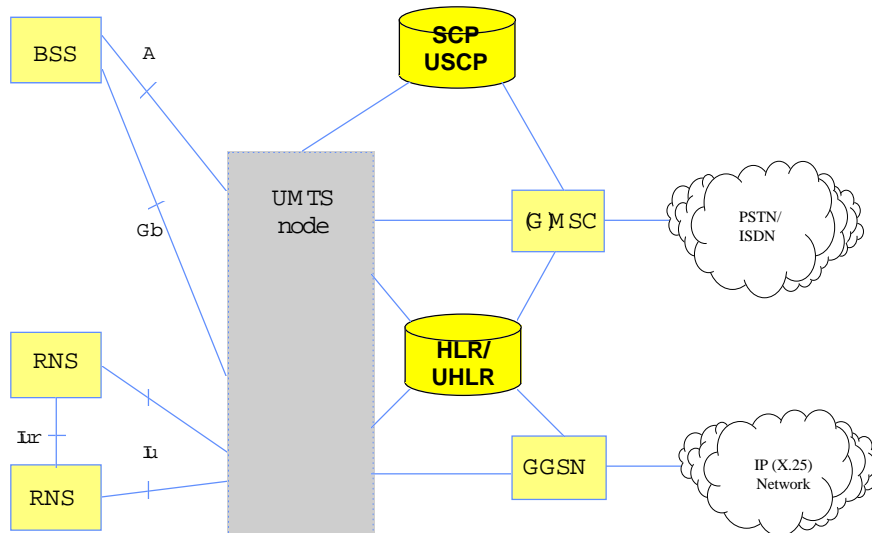Figure 97. Enhanced UMTS Node scenario with A and Gb interfaces to GSM BSSes.

1.9.4 Advantages

In addition to the advantages previously described, the support of A and Gb interfaces between the UMTS Node and the GSM BSS, provide:

Continuous usage of GSM BSS, and therefore full blown interworking between the GSM and the UMTS networks.

1.9.6 Disadvantages

Same disadvantage, as previously described.

1.10 Scenario 10

The Introduction of ATM (SVC) from the UMTS phase 1

Multimedia services are the main targets of IMT-2000/UMTS system. For the support of full multimedia services, it is considered that IMT-2000/UMTS NWs may be required to cover the range of QOS/bandwidth parameters from real time services such as voice, to best effort services on which users/applications do not require any QOS/bandwidth parameter. The demand for support not only of best effort but also of real time services may be occurred at this moment but only not be realized. So the requirement may not wait for UMTS phase 2.

In this situation, applying ATM technology is considered to be valuable for IMT-2000/UMTS core NWs. It is noted that IMT-2000/UMTS core NWs are required to set-up/manage ATM SVC links for the dynamic set-up of user/application demanding QOS/bandwidth parameters, if they want to take full advantage of ATM ability and support high quality of QOS/bandwidth services. According to this point, it is valuable that IMT-2000/UMTS NWs support ATM SVC links. But it should be also considered that the range of supported QOS/bandwidth parameters depends on the service strategy of each operator. And this brings one assumption that some operators may not support such a high QOS/bandwidth parameters. Considering such a situation, this scenario intends to support non-ATM networks configuration also.

This scenario intends to provide a total efficient management scheme of IMT-2000/UMTS core NWs which take into account of both circuit switched services and packet services. But on the other hand, there is possibilities of requirements that either circuit switched services or packet services can be separately managed in each specialized networks. This scenario also intends not to prevent such requirements.

This scenario intends to be applied in UMTS phase 1. It is necessary for the development of standardization in order to achieve the intention, that existing(or currently under developing) GSM/GPRS standards should be taken into account for reuse with some evolution points.

This scenario intends to allow IMT-2000/UMTS operators to introduce IP-NWs within the IMT-2000/UMTS NWs optionally in order to allow IMT-2000/UMTS operators to provide ISP services or other value added services. With ATM SVC link capability in the IP-NWs, IMT-2000/UMTS NWs are expected to have the capabilities of supporting end-end QOS/bandwidth services.
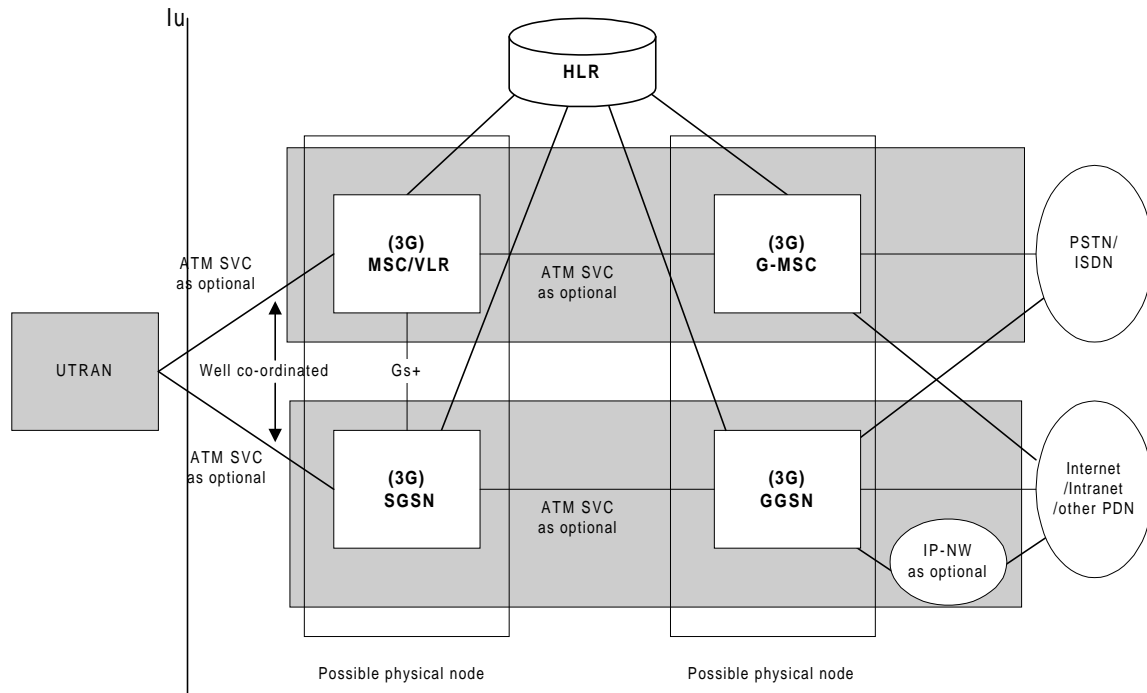
Figure 98 Scenario 14

1.10.1 Related Actions

A number of investigating items of this scenario are needed in the following areas:

- - Introduction of ATM SVC for QOS/bandwidth support

- - Support for high data bearer

- - Improvement of the co-ordination between circuit switched services and packet services in the mobility management.

- - else

1.10.2 Physical relation between circuit switched NW part and packet NW part

The relation between circuit switched NW part and packet NW part can be described as follows in the viewpoints of physical configuration (mapping) of logical nodes, MSC/VLR and SGSN or G-MSC and GGSN (or all the among) . Some physical node configuration examples as follows can be thought

a) Separation between all logical nodes

b) Integrated node of MSC/VLR and SGSN

c) Integrated node of G-MSC and GGSN

d) Integrated node among MSC/VLR, SGSN, G-MSC and GGSN

1.11 Scenario 11

Key :

Solid lines represent transmission paths;

Dotted lines represent signalling paths;

GMM - GSM Mobility Management;

UMM - UMTS Mobility Management;

GCM - GSM Communication Management;

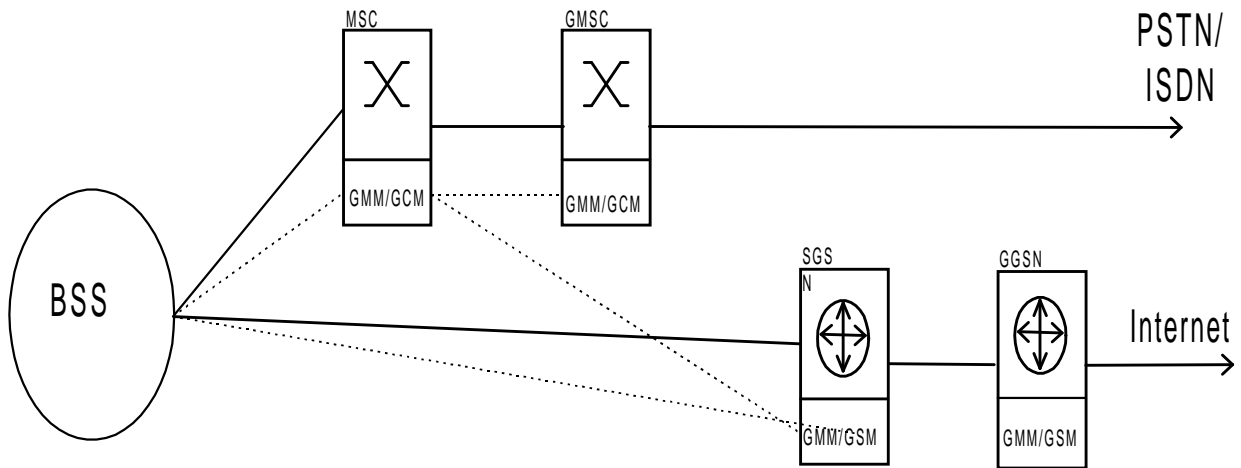UCM - UMTS Communication Management.

Evolutionary Steps

Figure 99

Figure 99 shows a GSM network before the evolution to UMTS is started. The HLR is deliberately not shown for the sake of clarity.
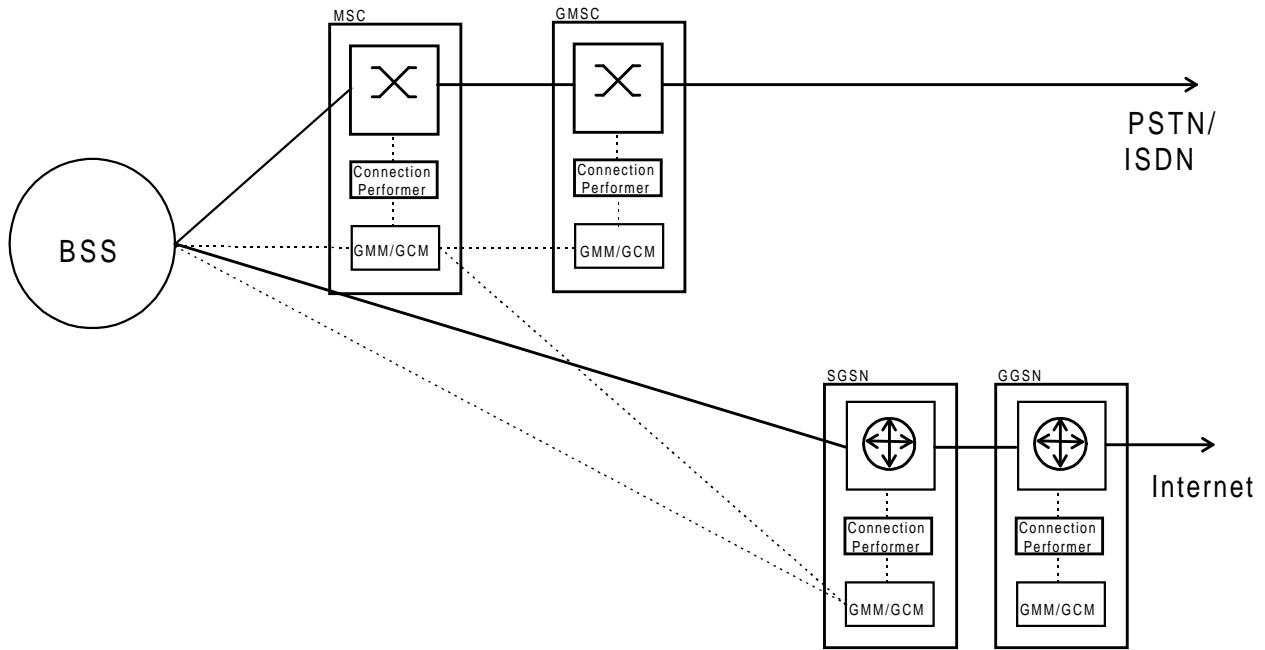
Figure 100

Figure 100 shows the separation of the mobility management and communication management functions from the switching or routing element. This is achieved by the introduction of a connection performer. The interface between the GMM and GCM functions and the connection performer shall be standardised and could possibly be based on MAP. A variety of open interfaces (to allow for different technologies) shall be used between the connection performer and the switching/routing element. At this stage all functions are still contained in the MSC/GPRS node.
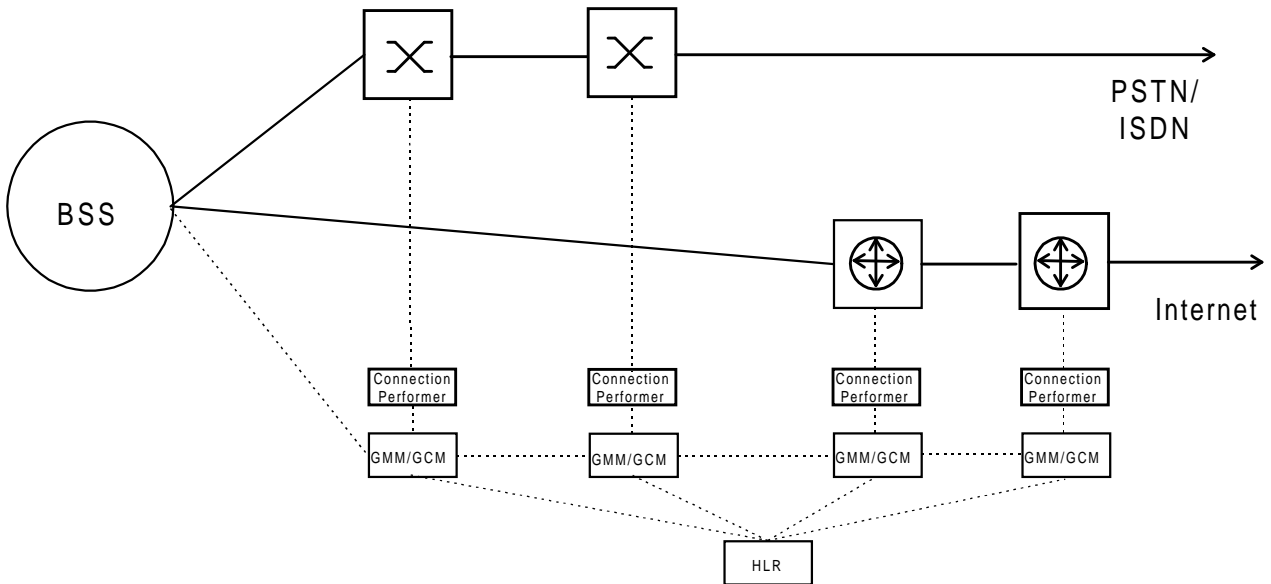

Figure 101

In Figure 101 the GMM and GCM functions and the connection performer have been physically separated from the switching/routing elements. However there is still one connection performer, one GMM function and one GCM function per switching or routing element. The switching and routing elements are now not mobile specific which will result in more competitive sourcing.
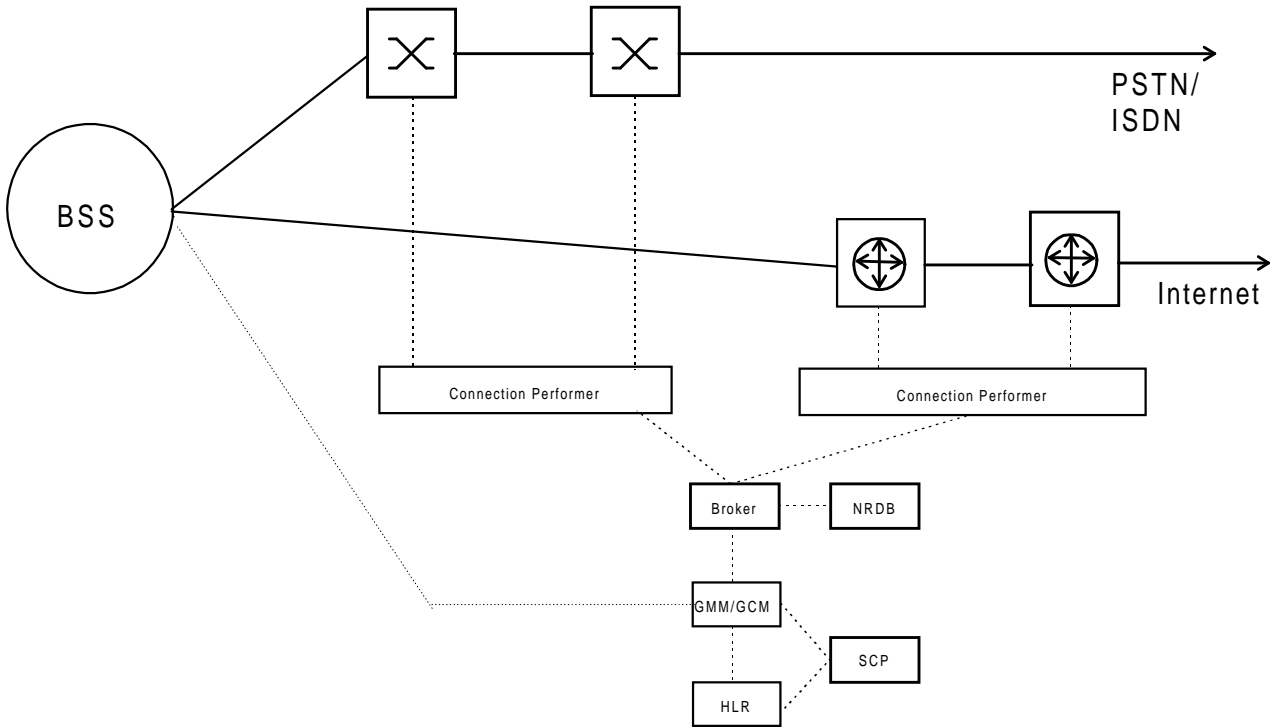
Figure 102

In Figure 102 the introduction of the broker allows a single GMM and a single GCM unit to control all switching and routing elements in the network. The connection performers have been rationalised to one per switching/routing technology. It is conceivable that the number of connection performers could be reduced still further to a single connection performer that can support multiple interfaces. Via the network resource database the broker has a knowledge of all available resources that can be used to service requests for network resources from the GMM and GCM functions. Abroker will control a single network. If a call involves more than one network the brokers of each network will communicate with each other to set up and manage the call.
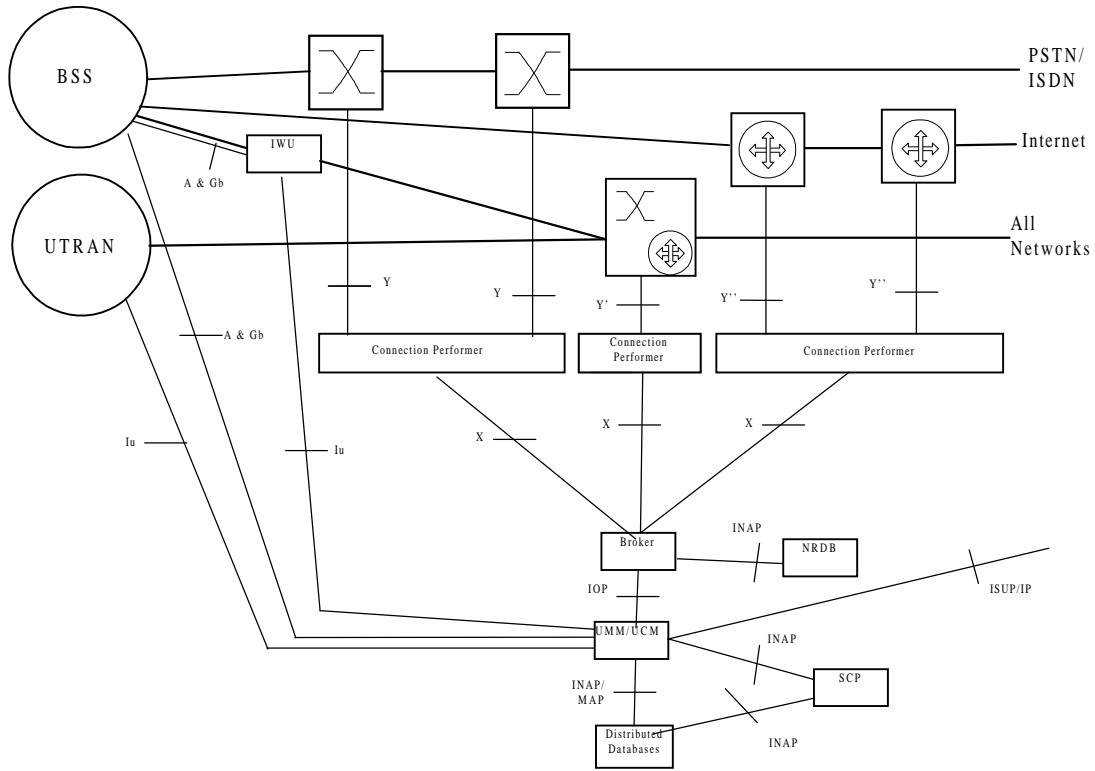
Reference point X - new reference point. Protocols operating across this reference point are FFS.

Reference points Y, Y' and Y'' - new reference points. Protocols operating across these reference points may vary depending on the technology of the switching or routing element and are FFS.

Figure 103

Figure 104

Figure 104 shows proposes protocol stacks for the Um and Iu reference points. The following points should be noted:

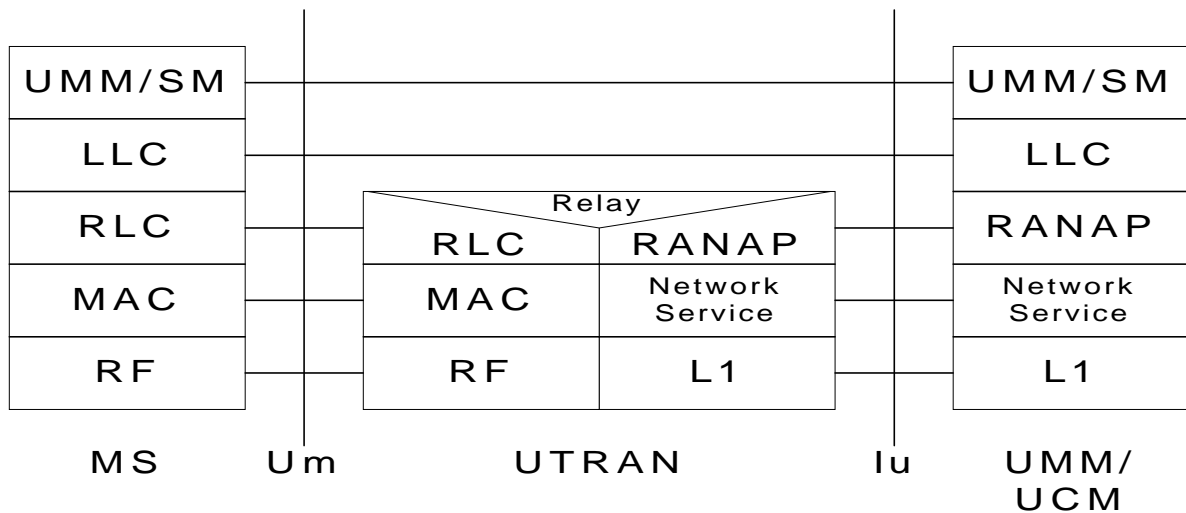1. Layer 1 of the Iu interface is not defined. It is considered prudent to await the outcome of the work item investigating the suitability of ATM for use in the core network;

(

2.   UMM is UMTS Mobility Management and is analogous with GMM and MM;

3.   RANAP is Radio Access Network Access Part and is analogous with BSSGP, BSSMAP and BSSAP.

In Figure 102 the UTRAN and a UMTS switching/routing node is introduced. The mobility management and communication management functions are now enhanced to cater for UMTS. The UMM and UCM are supersets of GMM and GCM. An Iu to A interworking unit is provided to allow handover between GSM and UMTS networks.

It is perceived that initially a UMTS core network with minimal capacity will be deployed. This is necessary to allow operators to immediately start earning revenue from the very large investment required to deploy the UTRAN. Additionally it will avoid the need to deploy additional GSM switching and routing nodes to support UMTS users. As the volume of UMTS traffic increases additional UMTS switching/routing elements will be deployed. As GSM switching and routing elements come to the end of their lives they will be replaced by UMTS switching/routing nodes.

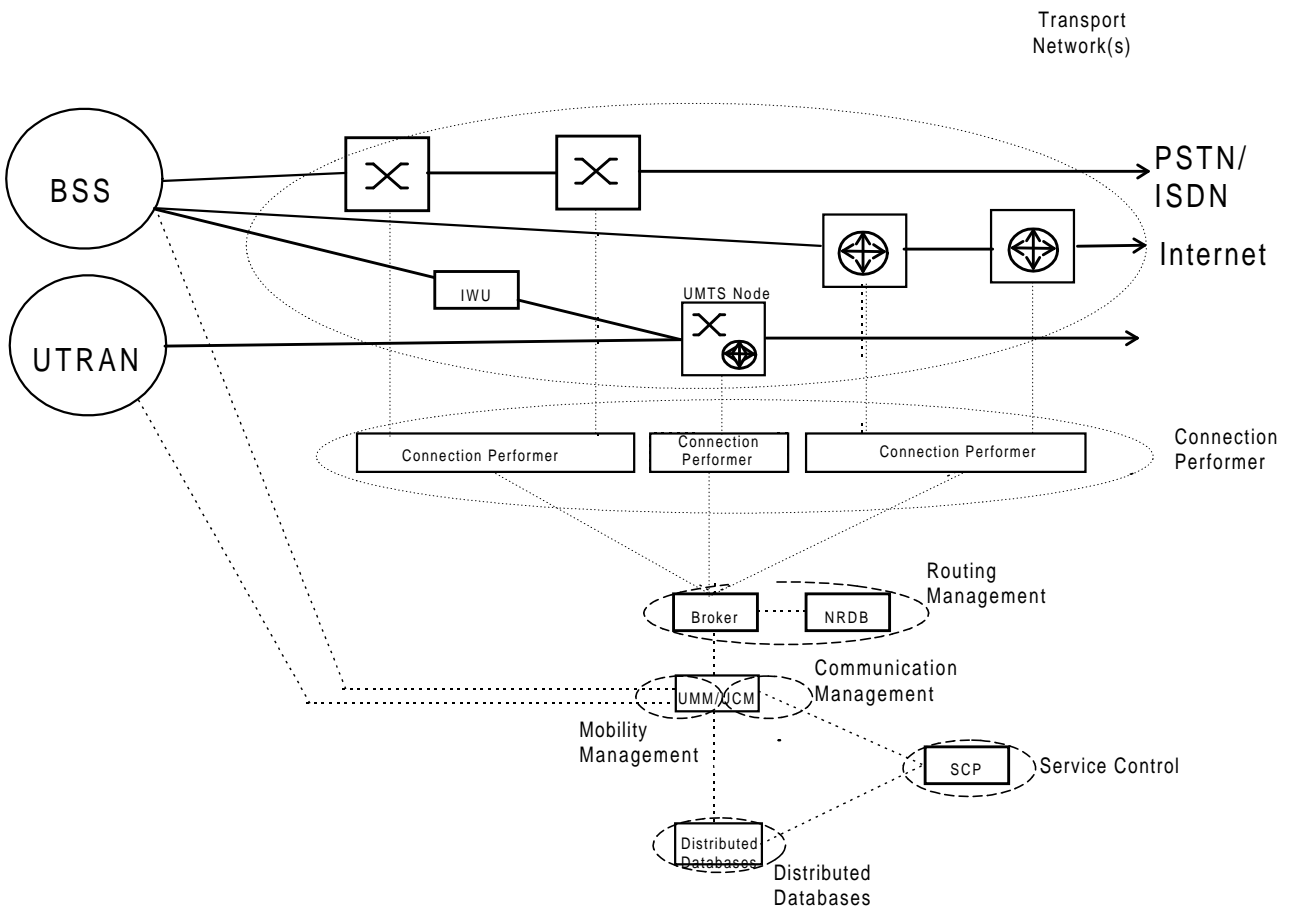**Mapping of Network Elements to Network Functions**

Figure 105

Functional Architecture

Figure 106 presents a proposed functional architecture for a UMTS core network. Table 1 identifies the closest GSM/IN equivalent of each functional component.

UMTS Functional	Closest GSM	Description

Element	Equivalent	
API	?	Application Programming Interface
SCM	?	Session Control Manager
CCM	?	Call Control Manager
MM	MM	Mobility Manager
SDF	SDF	Service Data Function
SCF	SCF	Service Control Function
SubDB	HLR	Subscriber Database - HLR + UMTS bits
SDB	AuC, EIR	Security Database
NRDB	?	Network Resource Database - A distributed database that contains a map of the network(s) and the available resources of each element.
Intelligent Bus	?	This bus identifies the destination of a message from the message type and therefore addressing is not required. It also provides security functions to ensure that the origin is a legal sender of a message and will provide protocol conversion .
Connection Performer	?	Translates the instructions created by the broker into instructions that are applied directly to the switching and routing elements of the transport network(s).
Broker		The broker decides how to supply the requested service and issues appropriate high level routing instructions.

Table 1

Description of a Call/Session Creation

The communication manager receives the request for a call or session to be created. One or more of the data base functions are used to confirm the authenticity of the customer, equipment and the call request. The Broker will then decide which technologies/networks will best meet the requirements and uses the NRDB to confirm that the required resources are available. The Broker then determines the optimal route and instructs the connection performer to make the connection. The Connection Performer then issues instructions to individual switches/routers to create the call. At anytime Service Control may modify instructions or data. Upon any successful creation, modification or termination the NRDB is informed of the resources that have been used or released.
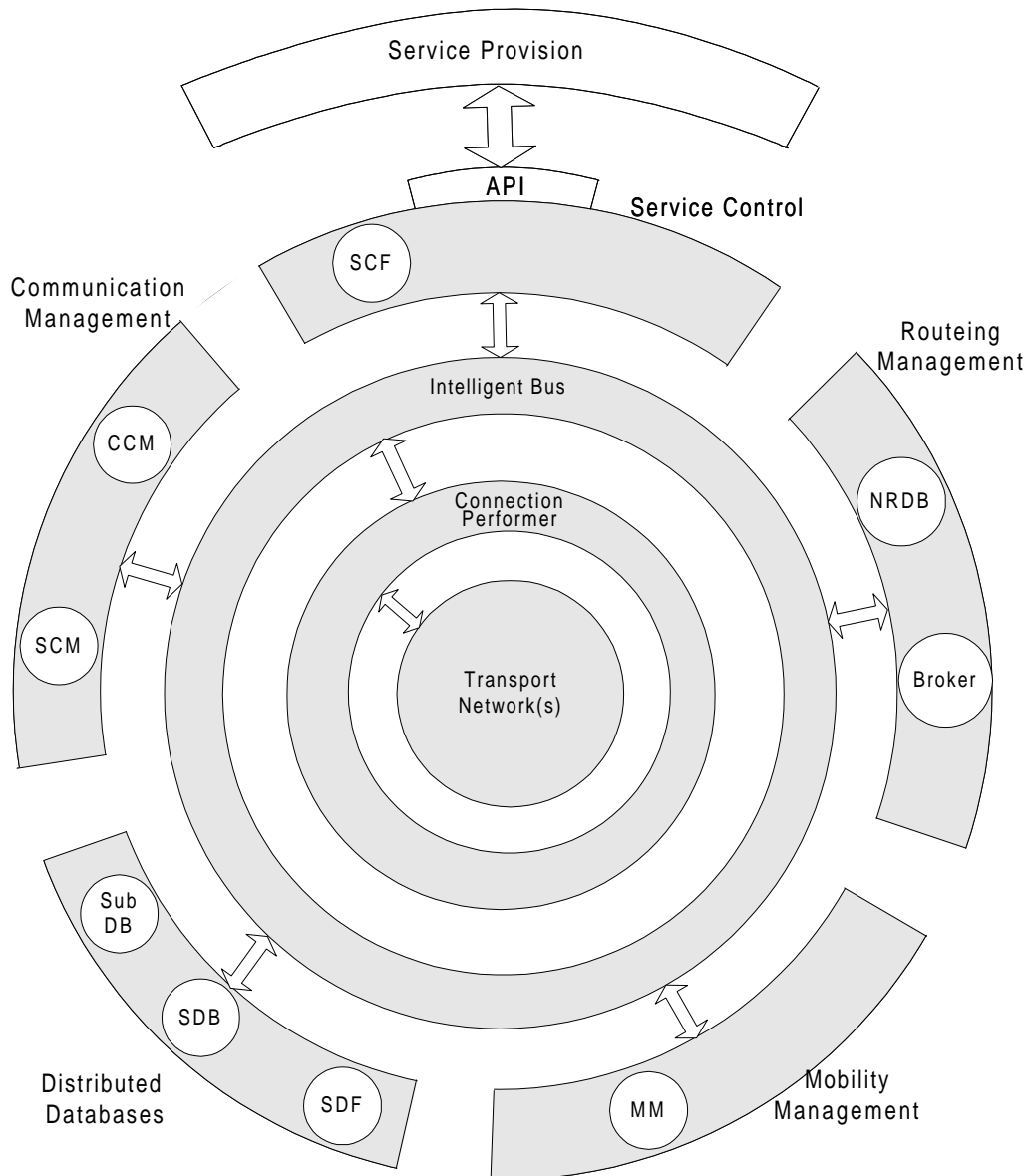
Figure 106. Functional model of UMTS

Possible Evolutionary Steps

Evolutionary steps could include: (This list is not intended to be a definitive list of evolutionary steps. Some steps could be divided further or combined together or re-ordered.)

1. Implement standardised interfaces between Communication Management and Mobility Management functions of the MSC/SGSN and the switching fabric.

2. Develop standalone Communication Management and Mobility Management functions.

3. Relocate the Communication Management and Mobility Management functions.

4. Transport networks can now be extended using non mobile specific switching elements.

5. Develop and deploy the Intelligent Bus.

6. Develop and deploy Broker.

7. Develop and deploy distributed data bases

1.12 Scenarios related to the intelligent control of packet services

1.12.1. No CSE control of packet services

In this case the CSE would be connected to MSC's only. Neither GSN's nor eventual UMTS CN (as in some of the scenarios) could be controlled by the CSE.

Figure. 108

1.12.2. CSE control of packet services

By an introduction of an appropriate interface between CSE and GSN or eventually UMTS CN it would be possible to apply intelligent network control to packet services.

Figure 109

Appendix 2 Mobility Management

1.3   Mobility Management

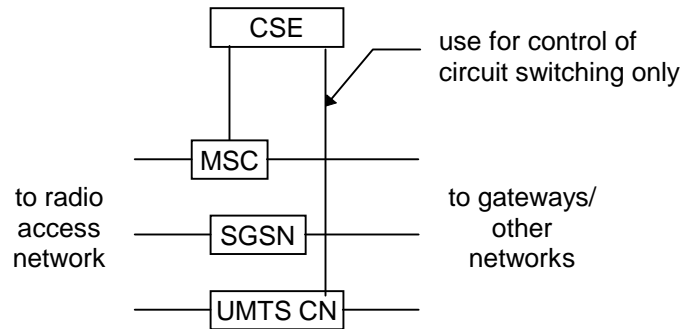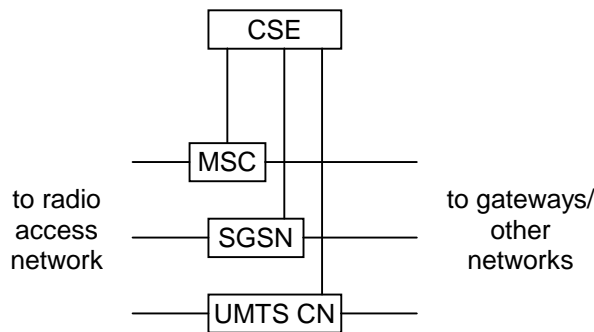## 1.3.1 Common or separate LM/MM from terminal point of view

1.3.2 Common or separate LM/MM from CN point of view

Comparison of 2 MM and one MM as proposed in the different scenarios in 23.20

The scenarios given in 23.20 use either a single MM (in an integrated switch or separate physical switches) , two MMs in separate physical entities with or without the Gs link.   The table X liststhe possibilities for some of the MM specific procedures and related functionality for the three architectures . In the case of one MM and two separate physical switches, there will be some signalling traffic between the separate physical switches and/or registers, which has not been considered. The functionality of Gs is assumed equivalent to the functionality of Gs in GSM/GPRS.

Procedure	One MM	Non-integrated switch, 2 MM, no Gs interface	Non-integrated switch, 2 MM, with Gs interface
Attach	Combined	Separate	Combined
Location/Routing area update	Combined	Separate	Combined
Periodic update	Combined	Separate	Combined
Detach	Combined	Separate	Combined
Update to the HLR	Single	Separate	Separate
Subscriber information	Single	Separate	Separate
Authentication	Single authentication	Separate	Single
Ready State (Cell info)	Handled in the UTRAN	Handled in the UTRAN	Handled in the UTRAN
First page (Open issue: Paging area greater than one RNC)	Handled by the UTRAN	Handled by the UTRAN	Handled by the UTRAN
Second Page (for a different type)	2 Options 1) Can be sent on ACCH by UMSC if a packet session exits 2) Handled by UTRAN; if UTRAN knows cell info, page in cell or send in ACCH	Must be handled by the UTRAN. Requires co-ordination at the UTRAN.	Same as integrated core
Mobile not reachable	Single flag	Separate flags	May be single
Suspend/Resume (No need for the procedure is foreseen at the moment, requirement is ffs)	Can be handled in the CN (easier)	Must be handled in the UTRAN	Can be handled in the CN

Table X Some of the MM specific procedures and related CN functionality for comparison between one and two MMs

When considering the above table, it should be noted that L3-MM consists of MM common, MM specific and of upper layer service provision procedures. The radio interface efficiency of one MM and two MM specific procedures using the Gs interface is the same based on the above table.

The option with the Gs interface requires additional messaging within the CN both across the Gs interface itself and to the HLR/AuC. However, the procedures for upper layer service provision, if similar to GSM 04.08, have to be run equally irrespective of the number of MM instances in the CN.

Overall it seems possible to achieve the same functionality using any of the three architectures for the procedures given in Table X with co-ordination in the UTRAN. Support of other procedures (e.g. Iu streamling) are for ffs. The level of co-ordination required in the UTRAN for all the procedures are also for ffs.

1.3.3 Signalling procedures applicable both 2MM and 1MM concepts

The TMSI signature concept would mainly be used during the IMSI attach procedure and during the location update procedure. (The former may invokes the latter) However, it may also be used in almost all cases when authentication is performed e.g. call setup. Note that if the TMSIS is sent in the clear, then a new one should be issued.

As the use of a P-TMSI signature is already defined within GPRS, only the modifications necessary for GSM shall be shown below.

1.3.3.1 IMSI attach

Figure 1 shows the signalling procedure for *a first time (IMSI based) attach*. The following list explains the relevant steps involved in the procedure.
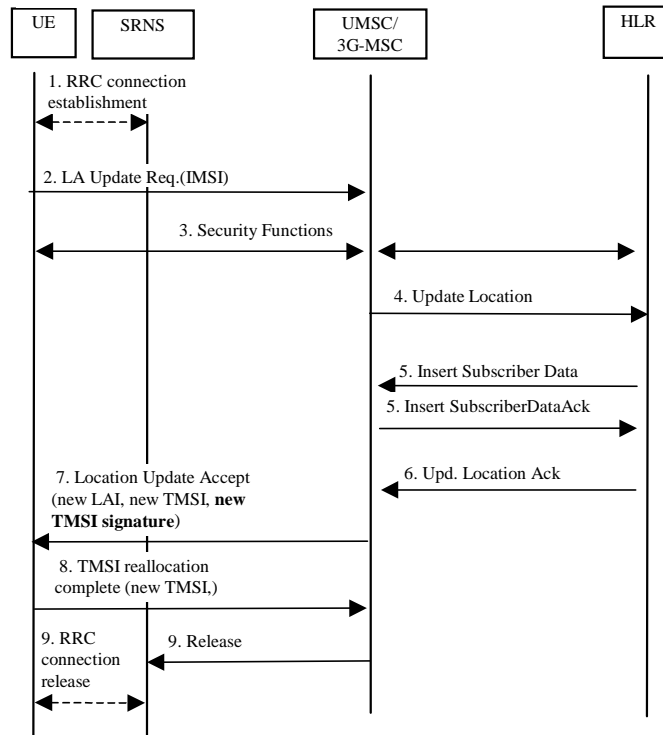

Figure 110 - Attach Procedure using TMSI signature

1). An RRC connection is established.

2). Apon the very first attach towards the network, the MS shall send a Location Area Update Request message towards the MSC/UMSC, indicating an IMSI attach, and identifying itself with IMSI.

2 – 6) The LA updating procedure shall be carried out as per normal within the network.

7). The MSC/UMSC shall optionally generate and send a TMSI signature within the Location Area Update Accept message to the MS, which will be stored by the MS.

8) The MS acknowledges the new TMSI.

9). The RRC connection may be released.

1.3.3.2 Location Area update

Figure 2 shows the signalling for a location update procedure involving change of 3G-MSC / UMSC. Note that when the authentication procedure using TMSI signature is successful, security functions using Ki are no longer required. The following list explains the relevant steps involved in the procedure.
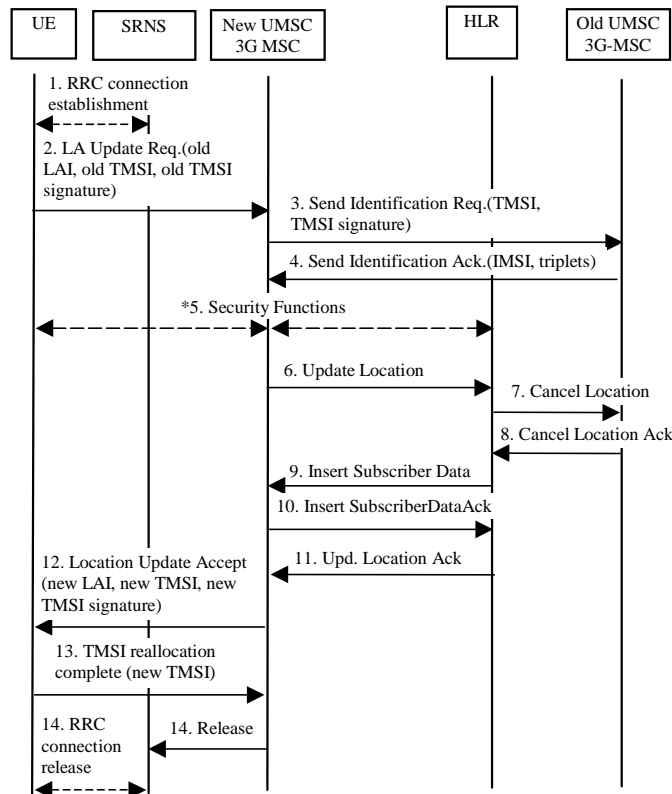
Figure 111 Location Update using TMSI signature

1) An RRC connection is established.

2) The UE shall send a Location Area Update Request (old LAI, old TMSI, old TMSI signature) towards the new UMSC/MSC.

3-5) The new UMSC/MSC shall send a Send Identification Request (TMSI, TMSI signature) to the old UMSC/MSC. The old UMSC validates the old TMSI signature and responds with an appropriate error cause if it does not match the value stored. This should initiate the security function in the new UMSC. Otherwise, the old UMSC responds with a Send Identification Acknowledge (IMSI, Authentication triplets).

6-11) The LA updating procedure shall be carried out as per normal within the network.

12) The new UMSC shall optionally generate and send a TMSI signature within the Location Area Update Accept message to the UE.

13) The UE acknowledges the new TMSI.

14) The RRC connection may be released.

1.3.4   Location Management and Mobility Management concept overview - 2MM Concept

From a logical point of view, the Core Network (CN) consists of two domains, a PSTN/ISDN domain with evolved MSC/VLR, 3G_MSC/VLR, as the main serving node and an IP domain with evolved SGSN/GGSN, 3G_SGSN and 3G GGSN, as the main serving nodes, or one of these domains.

Each CN domain has its own Mobility Management (MM) state machine. An UE, active in both 3G_MSC/VLR and 3G_SGSN, must keep two instances of its MM state machine, one for each CN domain. The two peers of the MM state machine are working independently (can be in different states), although associated to the same UE. The MM signalling aims to keep the peer entities synchronized.

As an introduction, **Figure** 112 below gives an overview of the UE connection principles within UMTS and the location management and mobility management concept described.
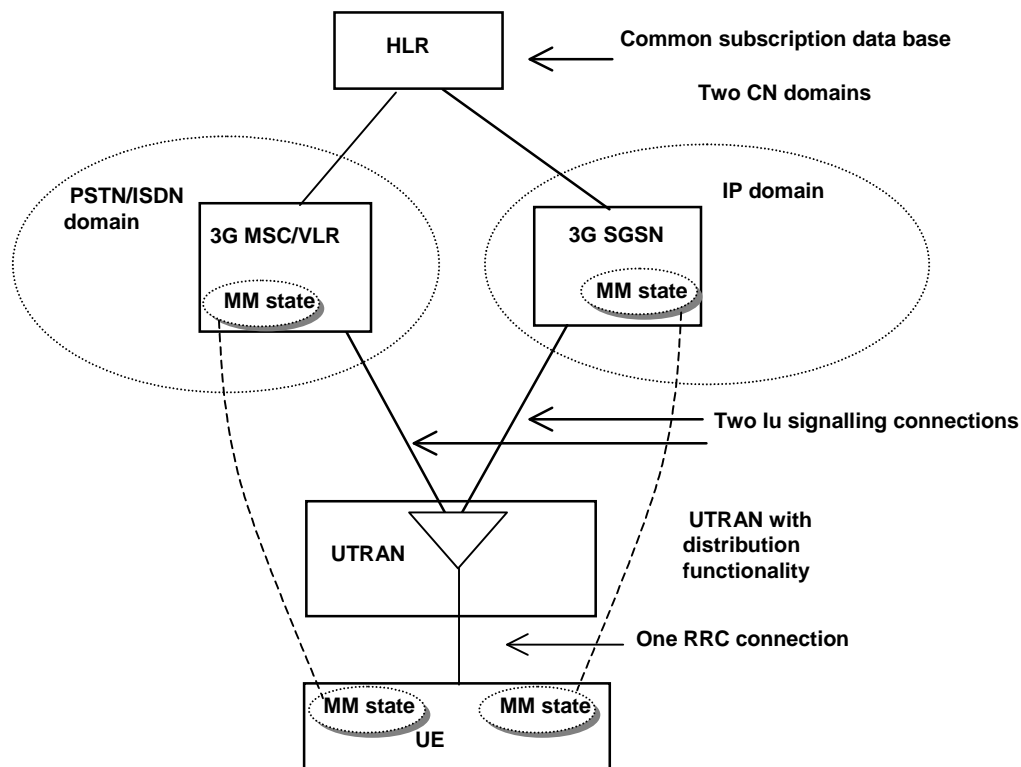
Figure 112. Overview of the UE connection principles within UMTS when the CN consists of both a PSTN/ISDN domain and an IP domain.

Each instance of the Mobility Management state machine has three main states, MM-DETACHED, MM-IDLE and MM-CONNECTED. In the MM-DETACHED state there is no communication going on between the UE and the corresponding CN node (3G_MSC/VLR or 3G_SGSN). The UE MM state machine does not react on system information related to the CN node. In MM-IDLE state no control or user plane connection exists between the UE and the CN node. The UE reacts on system information related to the CN node and updates the CN node with its location. In

MM-CONNECTED state at least a control plane and possibly one or more user planes exist between the UE and the CN node. In this state the UE mobility is handled on radio resource control level.

The aim of UTRAN is to offer one unified set of radio bearers which may be used for bursty packet traffic and for traditional telephony traffic. This leads to the conclusion that only one logical control channel structure will be used for all kind of traffic.

The Radio Resource Control (RRC) has two modes, RRC Connected mode and RRC Idle mode. The RRC mode describes which identity is used to identify the UE. In RRC Idle mode the UE is identified by a CN identity such as IMSI, TMSI and P-TMSI. In RRC Connected mode the UE is assigned a Radio Network Temporary Identity to be used as UE identity on common transport channels. When the UE is allocated dedicated transport channels, it uses the inherent addressing provided by these transport channels.

Four different area concepts are used, Location Areas and Routing Areas in the Core Network as well as UTRAN Registration Areas and Cell Areas in UTRAN. Location Area is used by the 3G_MSC/VLR for paging the UE. Routing Area is used by the 3G_SGSN for paging the UE. UTRAN Registration Areas and Cell Areas are only visible in UTRAN and used in RRC-Connected mode.

IMSI and TMSI are used as UE identities in the PSTN/ISDN domain. IMSI and P-TMSI are used as UE identities in the IP domain.

1.3.4.1 Description of the Location Management and Mobility Management CONCEPT

1.3.4.1.1 Area concepts

Four different area concepts are used, Location Areas and Routing Areas in the Core Network as well as UTRAN Registration Areas and Cell Areas in UTRAN. For an UE that is registered in the PSTN/ISDN domain of the core network, this domain knows in which Location Area, LA, the UE is. For an UE that is registered in the IP domain of the core network, this domain knows in which Routing Area, RA, the UE is.

To provide additional area granularity there exist areas only known within UTRAN.

9.3.3.1.1.1 Location areas

The PSTN/ISDN domain of the core network uses Location Areas. The temporary identity TMSI is allocated to be unique within a LA. The PSTN/ISDN domain of the core network will normally request paging in a LA. The UE informs the PSTN/ISDN domain of the core network about its present location with a location area update procedure.

9.3.3.1.1.2 Routing areas

The IP domain of the core network uses Routing Areas. The temporary identity P-TMSI is allocated to be unique within a RA. Paging is normally ordered in a RA. The UE informs the core network about its location with a routing area update procedure.

Note that the routing area concept here differs from the routing area in GSM, which in a sense corresponds to URA (see below) in UMTS.

9.3.3.1.1.3 UTRAN internal areas

UTRAN internal areas are used when the terminal is in RRC-Connected mode (see chapter 3.3). The areas are used for UTRAN initiated paging. UTRAN internal area updating is a radio network procedure and the UTRAN internal area structure should not be visible outside UTRAN. In RRC connected mode, the UE position is known on cell level or on UTRAN Registration Area (URA) level. RNTI is used as a temporary UE identifier used within UTRAN and allocated to be unique within an URA. Note that the URA thus corresponds, in a sense, to the routing area in GSM.

9.3.3.1.1.4 Connections between the different areas

The areas are not totally independent. Restrictions are included for GSM compatibility reasons but also for system simplification reasons. The following restrictions exist:

a) One URA consists of a number of cells. The cells normally belong to the same RNC, but this assumption may not be a requirement (ffs).

b) One RA consists of a number of URA:s belonging to RNC:s that are connected to the same 3G_SGSN.

c) One LA consists of a number of URA:s belonging to RNC:s that are connected to the same 3G_MSC/VLR.

d) One RA is handled by only one 3G_SGSN.

e) One LA is handled by only one 3G_MSC/VLR.

f) As in GSM, one RA is a subset of one, and only one, LA, meaning that a RA cannot span more than one LA. Totally separated LA and RA structure is ffs. One advantage with coinciding LA and RA borders is the use of one common RRC connection for both the location area update and the routing area update.
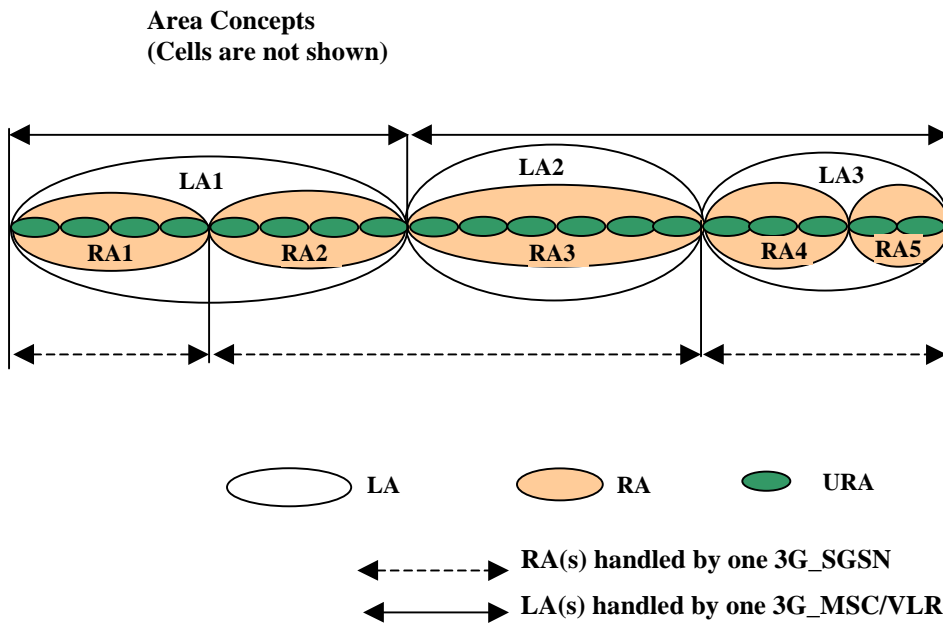

**Area Concepts
(Cells are not shown)**

Figure 114. Relation between different areas

1.3.4.1.2   The MM state machine

Each CN domain has its own Mobility Management (MM) state machine. An UE, active in both 3G_MSC/VLR and 3G_SGSN, must keep two instances of its MM state machine, one for each CN domain. The two peers of the MM state machine are working independently (can be in different states), although associated to the same UE. The MM signalling aims to keep the peer entities synchronized.

Further in this document the instance is called CMM if it is related to a 3G_MSC/VLR node and PMM if it is related to a 3G_SGSN node. Below are the main states for the MM state machine described.

MM-IDLE (CMM-IDLE or PMM-IDLE)
In the MM-IDLE state there is no signalling connection established between the UE and the corresponding CN domain.

In MM-IDLE state the UE initiates Location Area Update to 3G_MSC/VLR and Routing Area Update to 3G_SGSN when crossing corresponding area borders or periodically.

MM-CONNECTED (CMM-CONNECTED or PMM-CONNECTED)
In the MM-CONNECTED state there is one signalling connection established between the UE and the corresponding CN domain. There may also exist one or more UP connections between the corresponding CN domain and the UE.

MM-DETACHED (CMM-DETACHED or PMM-DETACHED)

In state MM-DETACHED there is no information regarding the UE location in the corresponding CN domain. As a consequence this CN domain can not reach the UE. The UE will not perform any updating traffic to this CN domain when it is detached.

There may also be a MM-NULL state. In the UE this state will correspond to power off or maybe a "no SIM" condition. For the respective CN domain the NULL state will correspond to the MM-DETACHED state.

For each state transition there can be several events that triggers the transition. Some of them are described below.

Moving from MM-IDLE to MM-CONNECTED:

The state transition is performed when a signalling connection is established between the UE and the CN node. In GSM this state transition is triggered for example by the messages CM_SERVICE_REQUEST or PAGE_RESPONSE.

Moving from MM-CONNECTED to MM-IDLE:

The state transition between MM-CONNECTED and MM-IDLE is performed when the signalling connection is released between the UE and the CN node, e.g. when a CM service is released and no other CM service is established for concerned UE in the CN node.

An RRC initiated radio link failure may also trigger this state transition.

Moving from MM-IDLE to MM-DETACHED:

The transition may be triggered by some action from the user of the UE but an expiring timer in the network could also trigger it. The UE is marked as MM-DETACHED in the corresponding CN domain.

1.3.4.1.3 The RRC state machine

The RRC state machine is a description model of how the UE and the UTRAN co-operate regarding RRC functionality. The RRC state describes the state of the UE in the UTRAN. Here follows a brief description of the RRC state machine, for more information see [3] and [4].

Note: RRC idle mode and RRC connected mode refer to the UE idle mode and UE connected mode respectively in [3] and [4].

The RRC state machine exists as peer entities, one in the UE and one in UTRAN. Apart from transient situations and error cases they are synchronized. The figure below illustrates the main modes/states of the RRC state machine.
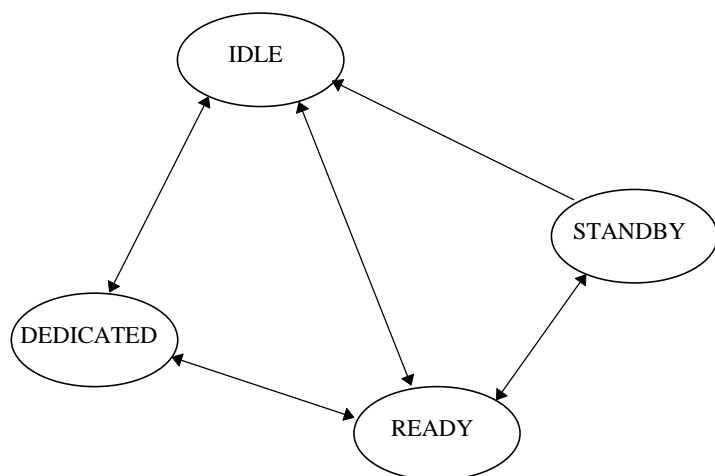

Figure 115. RRC modes, main RRC states and main mode/state transisions

RRC-Idle_mode
In the Idle mode there is no connection established between UE and UTRAN. There is no signalling between UTRAN and the UE except for system information that is sent from UTRAN down link on a Broadcast channel to the UE. The UE can also receive paging messages with a CN identity on the PCH. There is no information on the UE stored in UTRAN in this state.

RRC-Connected_mode
In the Connected mode the main states are Cell Connected state and URA connected state. In this mode there is one RNC that is acting as Serving RNC (SRNC), and an RRC connection is established between the UE and this SRNC.

- When the UE position is known on cell level, the UE is in the cell connected state. When in cell connected state, the RRC connection mobility is handled by mobility procedures.

- When the UE position is known on URA level, the UE is in the URA connected state. The URA contains a set of cells. URA updating procedures provides the mobility functionality in this state.

1.3.4.1.4 The relation between MM state and RRC state for an UE

During non-transient conditions the following relations are valid between MM state and RRC state for an UE:

a) RRC idle mode ⇔ MM-IDLE or MM-DETACHED in both domains

b) RRC connected mode ⇔ MM-CONNECTED in one or both CN domains

Figure 116 and Figure 118 illustrate two examples on the relations between the RRC and MM state machines.
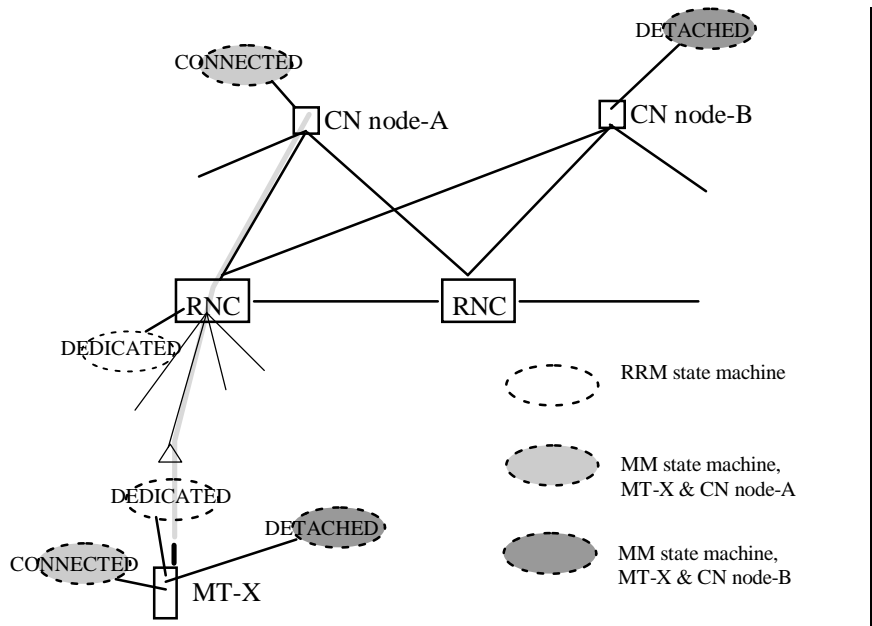

Figure 116. Instances of MM state and RRC state machines for a UE with established connection to 3G_MSC/VLR and idle related to 3G_SGSN.
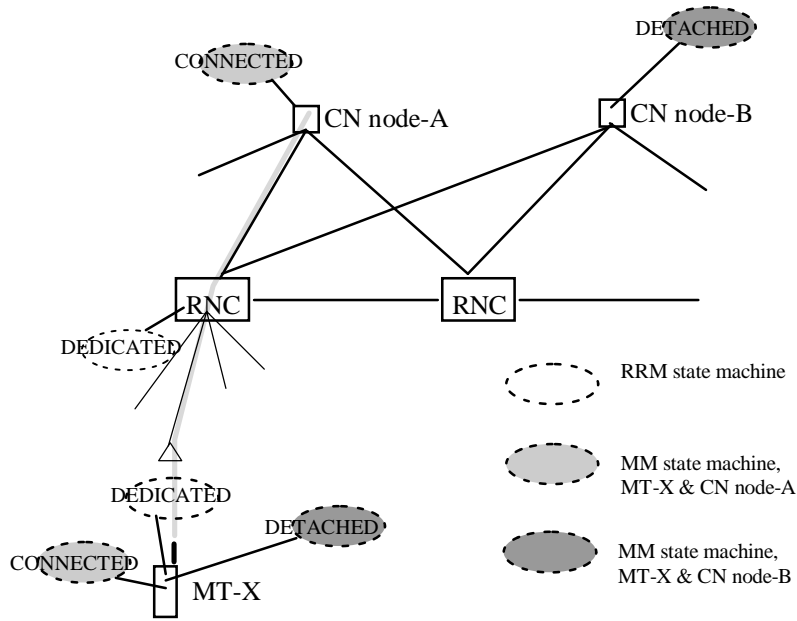
Figure 118 Instances of MM state and RRC state machines for a UE with no established connection to any CN node

1.3.4.1.5   Registration and location update

Registration in the respective CN domain is done initially (after UE being de-registered due to e.g. power off) and then when the respective CN registration area is changed a location update is performed. In addition, periodic updating can be performed towards the CN domains. Here follows descriptions of when the respective CN registration area is changed. The used mechanism is the same for the respective CN domain.

9.3.3.1.4.1   Location area update

Location area update is done by the UE to inform the PSTN/ISDN domain of the core network that the UE has entered a new location area. In case the new location area is in an area served by another 3G_MSC/VLR, the location area update also triggers the registration of the subscriber in the new 3G_MSC/VLR and a location update towards the HLR.

Location area update is only initiated by the UE when the UE is in state CMM-IDLE, and this independently of the PMM state.

If the UE is CMM-IDLE but RRC connected, which means that there is a connection to the IP domain of the core network, location area update is also performed when the UE enters a new location area.

9.3.3.1.4.2   Routing area update

Routing area update is done by the UE to inform the IP domain of the core network that the UE has entered a new routing area. In case the new routing area is in an area served by another 3G_SGSN, the routing area update also triggers the registration of the subscriber in the new 3G_SGSN and a location update towards the HLR.

Routing area update is only initiated by the UE when the UE is in state PMM-IDLE, and this independently of the CMM state.

If the UE is PMM-IDLE but RRC connected, which means that there is a connection to the PSTN/ISDN domain of the core network, routing area update is also performed when the UE enters a new routing area.

1.3.4.1.6   Paging initiated by CN

Here follows a possible solution with a page co-ordination within the UTRAN. Other alternatives are possible.

- A CN node requests paging only for UE in MM-IDLE state. Paging from a CN node is done independent of the MM state of the UE in the other CN domain.

- In this alternative with page co-ordination in UTRAN, the UE does not need to listen to the PCH (Page Channel) in RRC connected mode. (At least not when UE is allocated a dedicated channel.)

- At each page request received from a CN node, the RNC controls whether the UE has an established RRC connection or not. For this, the context that is build up in the SRNC for UE in RRC connected mode must contain the IMSI, i.e. the UE identity common for the two CN domains.

- If no context is found for the UE, "normal PCH paging" is performed. This implies transfer on the Paging channel of a page message indicating the UE paging identity received from the CN and a CN domain type indication.

- If a context is found, a "CN paging message" is transferred using the existing RRC connection. This message indicates then the UE paging identity received from the CN and a CN domain type indication.

1.3.4.1.7 Signalling connection establishment

A signalling connection between the UE and a CN node refers here to a logical connection consisting of an RRC connection between UE and UTRAN and an Iu signalling connection between UTRAN and the CN node. The signalling connection is used for transfer of higher layer (MM, CM) information between the UE and the CN node.

At a CM service request to one of the CN domains, UE will only request establishment of a new signalling connection when no such connection exists towards the applicable CN domain.

If no RRC connection exists, this is established in conjugation with (before) the transfer of the signalling establishment request. At the RRC connection establishment, an UE context is built up in the SRNC.

If an RRC connection is already established, the UE will send the signalling establishment request using that RRC connection.

At reception of the signalling establishment request, the SRNC will establish an Iu connection towards the CN node indicated by the CN domain type received from UE.

1.3.4.1.8 Relations between SRNS relocation and Location registration

This chapter is included in order to clarify the need for separate handling of MM registration area (LA and RA) information in RRC idle mode respective in RRC connected mode. The following example illustrates relations between SRNC relocation, registration area (LA/RA) change and location/routing area updates.

Note that the example is based on the assumptions that one RNC can set up Iu connections to only one 3G_MSC/VLR and only one 3G_SGSN, and that the CN node is configured to only send page to the RNC(s) that is controlling cells within the relevant LA/RA.

Preconditions:

- LA1 (Location Area 1) is handled by 3G_MSC/VLR1 and LA2 is handled by 3G_MSC/VLR2

- RA1 (Routing Area 1) is handled by 3G_SGSN1 and RA2 is handled by 3G_SGSN2

- UE is registered in LA1 in 3G_MSC/VLR1 and in RA1 in 3G_SGSN1

- The UE is in PMM-CONNECTED state and a signalling connection exists between UE and 3G_SGSN1

- The UE is in CMM-IDLE state and no signalling connection exists between UE and 3G_MSC/VLR1

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

The UE can always (at least in normal working states) identify the present available MM registration area (LA respective RA) associated with the respective CN domain. The determination of the present area differs depending on the state of the UE. For UE in RRC idle mode (UE with no ongoing communication with the network) it is the cell selection mechanism in the UE that is used. For UE in RRC connected mode it is the UTRAN that determines the area (although a change can implicit be initiated by the UE).

It is the network that supplies this MM information to the UE. For UE in RRC idle mode the MM information is provided by the system information broadcasting function. For UE in RRC connected mode, the MM information is supplied by the SRNC to the UE at each change of registration area. This leads to that in RRC connected mode, the MM registration area information sent on broadcast channel is not used.
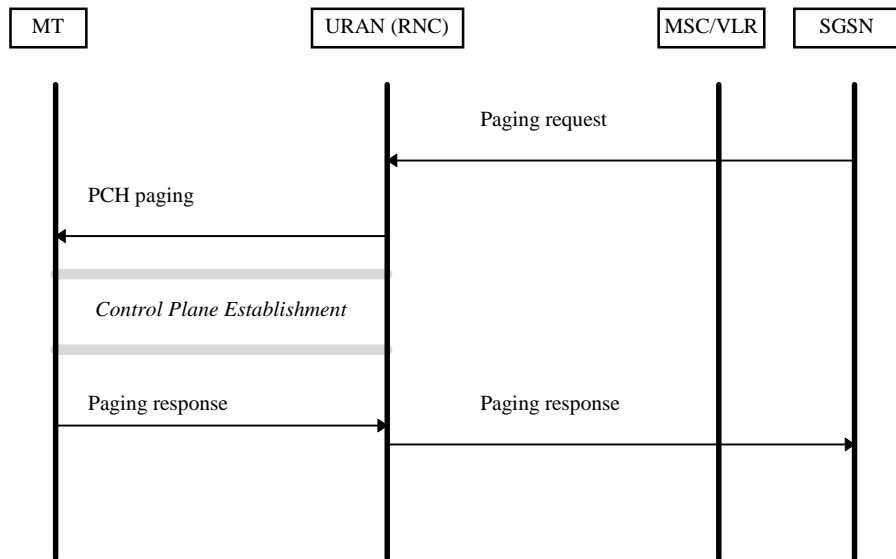

Figure 120. Illustration of the preconditions in the described example. In this figure MSC stands for 3G_MSC/VLR and SGSN for 3G_SGSN.

The UE moves now further towards right, leaving the coverage area of cells controlled by RNC1, and resulting in that the UE has dedicated channel(s) established to cell(s) within only RNC2. This may result in the following sequence of events:

- The SRNC (RNC1) may decide to perform an SRNC relocation resulting in that the RNC2 becomes SRNC.

- After this SRNC relocation or combined with this procedure, the MM registration area information sent to the UE is changed and indicates now LA2 and RA2.

- The changed MM registration area information will result in that the UE initiates a location update, which results in a registration change from LA1 in 3G_MSC/VLR1 to LA2 in 3G_MSC/VLR2.

The area information can not be changed to indicate LA2 unless SRNC relocation has been performed. This since the location update signalling will be sent from the UE, by using the established RRC connection to SRNC, and then to the 3G_MSC/VLR to which the SRNC belongs.

1.3.4.2 MM System Information

The system information that is needed for the Mobility Management functionality contains parameters such as:

MCC, MNC, LAC, RAC, Periodic Location Area Update timer, and Periodic Routing Area Update timer.

In each UMTS cell (UTRAN cell) the network broadcasts MM system information on the broadcast channel. In RRC idle mode, when the UE camps on one cell, it receives all MM system information valid for this cell on the broadcast channel of the cell. The received MM system information is then the "current MM system information".

In RRC connected mode, it is the responsibility of the SRNS to control the current MM system information valid for the UE. At any changes, the established RRC connection is used for transferring the new MM system information to the UE. E.g. at SRNS relocation, the new SRNS shall have logic for sending applicable MM system information to the UE. This information is determined by e.g. the Location Areas and the Routing Areas handled by the respective CN node to which the SRNS can set up Iu signalling connections. At reception of new MM system information from the SRNC on the established RRC connection, the UE uses this new information as the "current MM system information".

At the RRC connection establishment, the UE uses the broadcasted MM system information of the cell where the establishment is made as the "current MM system information".

When the UE leaves the RRC connected mode and enters RRC idle mode, the UE uses the broadcasted MM system information of the chosen cell, which is determined by the UE idle mode cell selection/re-selection process that is then performed, as the "current MM system information".

The "current MM system information" is used by the MM functionality in the UE respecting the rules for the MM state of the respective MM state machine, see chapter "The MM state machine" and chapter "Registration and location update" in UMTS 23.20.

1.3.4.3 Location Registration signalling procedures

The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation.

Furthermore the list of parameters may not be complete, but should only be seen as examples of possible information carried by the messages.

1.3.4.3.1 Location Area update

This example shows location registration when changing Location Area including change of 3G-MSC/VLR and when the UE is in MM idle state towards the 3G_MSC/VLR.

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.

For each indicated MM message sent in this case to/from UE, the CN discriminator indicates 3G_MSC/VLR.
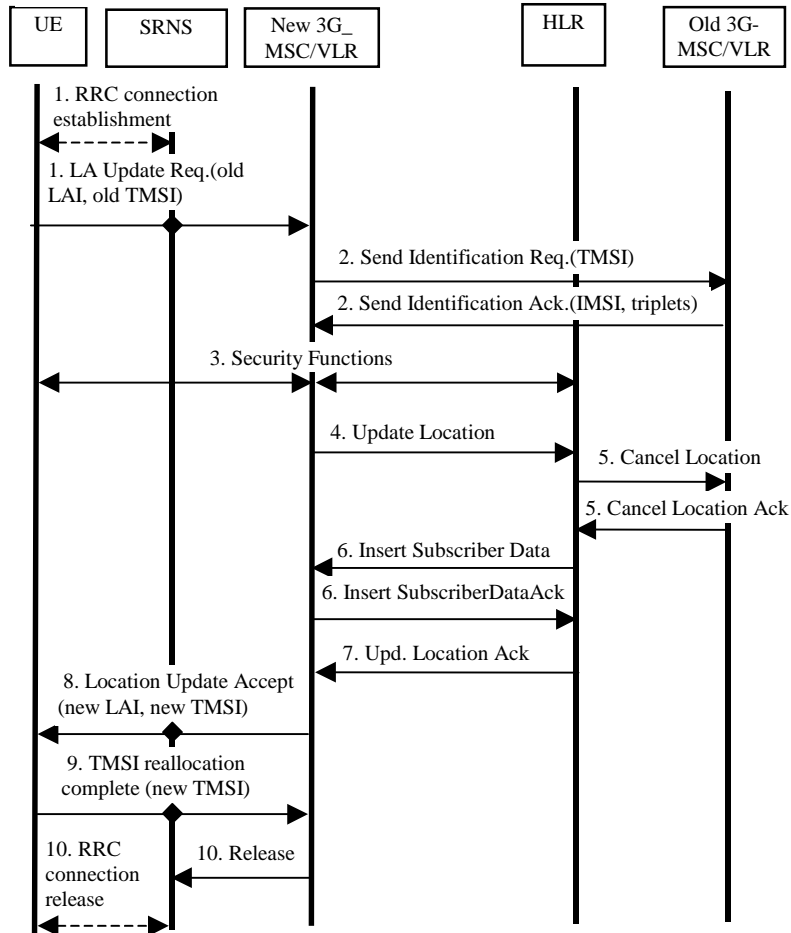
Figure 121: Interface information transfer for location update when changing VLR area

1) The RRC connection is established, if not already done. The UE sends the initial message Location Area Update Request (old TMSI, old LAI, etc.) to the new 3G_MSC/VLR. The old TMSI and the old LAI are assigned data in UMTS. The SRNS transfers the message to the 3G_MSC/VLR. The sending of this message to 3G_MSC/VLR will also imply establishment of a signalling connection between SRNS and 3G_MSC/VLR for the concerned UE. The 3G_MSC/VLR determinates the new Location Area for the UE. Whether the 3G_MSC/VLR derives the new LAI from information supplied by the UE or by the SRNS is ffs.

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 LA. If due to regional, national or
        international restrictions the UE is not allowed to attach in the LA or subscription checking fails, then the
        new 3G_MSC/VLR rejects the location area update with an appropriate cause. If all checks are successful,
        then the new 3G_MSC/VLR responds to the UE with Location Area Update Accept (new TMSI, new LAI).

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 may release the signalling
        connection towards the SRNS for the concerned UE. The SRNS will then release the RRC connection if
        there is no signalling connection between 3G_SGSN and SRNS for the UE.

1.3.4.3.2 Routing Area update

This example shows location registration when changing Routing Area including change of 3G_SGSN when the UE is
in MM idle state towards the 3G_SGSN.

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_MSC/VLR or be established only for
this location registration procedure towards the 3G_SGSN.

For each indicated MM message sent in this case to/from UE, the CN discriminator indicates 3G_SGSN.

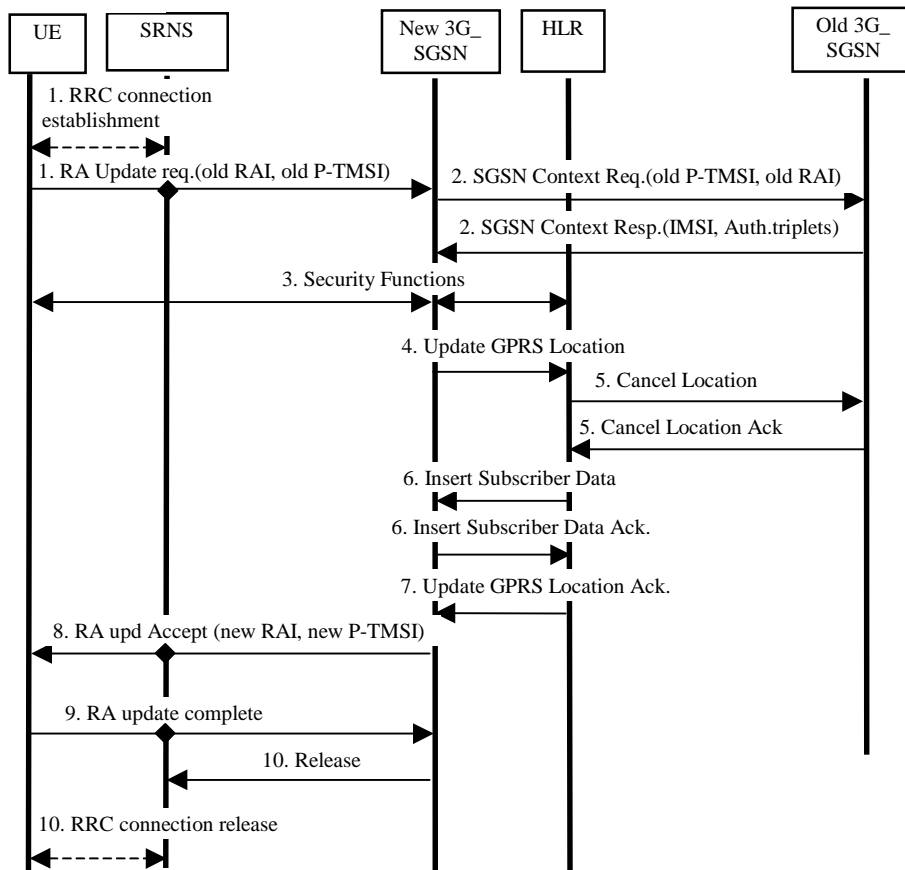Figure 122: Interface information transfer for Routing Area update when changing SGSN area (successful case)

1)   The RRC connection is established, if not already done. The UE sends the initial message Routing Area
        Update Request (old P-TMSI, old RAI, etc.) to the new 3G_SGSN. The old P-TMSI and the old RAI are
        assigned data in UMTS. The SRNS transfers the message to the 3G_SGSN. The sending of this message to

3G_SGSN will also imply establishment of a signalling connection between SRNS and 3G_SGSN for the concerned UE. The 3G_SGSN determinates the new Routing Area for the UE. Whether the 3G_SGSN derives the new RAI from information supplied by the UE or by the SRNS is ffs.

2) The new 3G_SGSN send an SGSN Context Request (old P-TMSI, old RAI) to the old 3G_SGSN to get the IMSI for the UE. (The old RAI received from UE is used to derive the old 3G_SGSN identity/address.) The old 3G_SGSN responds with SGSN Context Response (e.g. IMSI and Authentication triplets).

3) Security functions may be executed.

4) The new 3G_SGSN informs the HLR of the change of 3G_SGSN by sending Update GPRS Location (IMSI, SGSN number, SGSN address) to the HLR.

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

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

7) The HLR acknowledges the Update GPRS Location by sending Update GPRS Location Ack. to the new 3G_SGSN.

8) The new 3G_SGSN validate the UEs presence in the new RA. If due to regional, national or international restrictions the UE is not allowed to attach in the RA or subscription checking fails, then the new 3G_SGSN rejects the Routing Area Update Request with an appropriate cause. If all checks are successful, then the new 3G_SGSN responds to the UE with Routing Area Update Accept (new P-TMSI, new RAI, etc.).

9) The UE acknowledges the new P-TMSI with Routing Area Update Complete.

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

1.3.4.3.3 Periodic Registration towards both CN nodes

This example shows Periodic Registration to both the 3G_MSC/VLR and the 3G-SGSN (i.e. no change of registration areas) when the UE is in MM idle state and registered in both the 3G_SGSN and the 3G_MSC/VLR.

The illustrated transfer of MM signalling to/from the UE uses an established RRC connection. This RRC connection will be established, is in this case, only for the two registration procedures towards the 3G_SGSN and 3G_MSC/VLR.

For each indicated MM message sent to/from UE, the CN discriminator indicates either 3G_ SGSN or 3G_MSC/VLR.
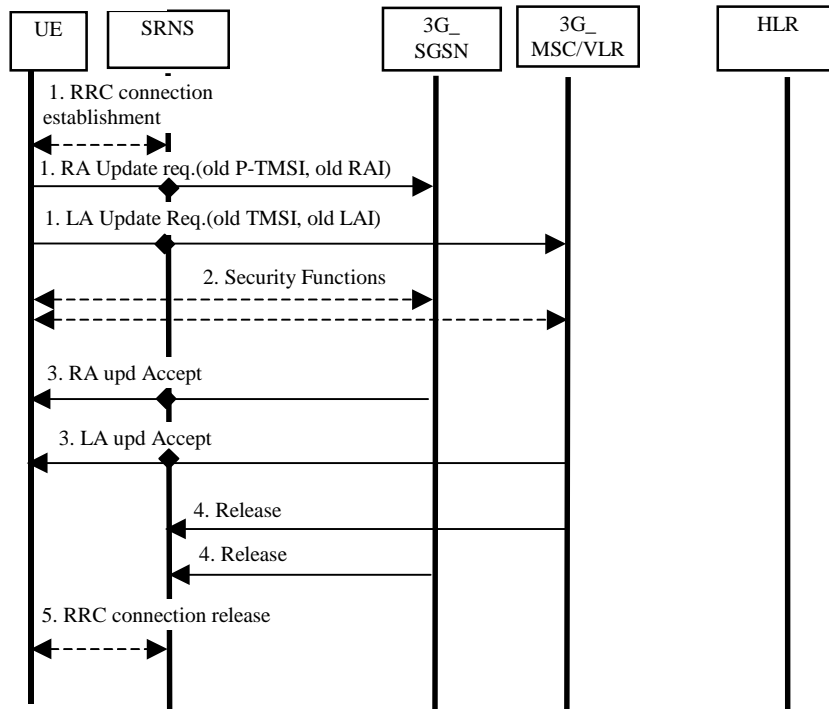
Figure 123: Interface information transfer for periodic registration to 3G_SGSN and 3G_MSC/VLR (successful case)

1) The RRC connection is established. The UE sends the initial messages Routing Area Update Request (old P-TMSI, old RAI, etc.) to the 3G_SGSN and Location Area Update Request (old TMSI, old LAI, etc) to the 3G_MSC/VLR. In both cases, the UE will indicate the cause periodic registration. The sending of the respective message to SGSN respective to MSC/VLR will also imply establishment of a signalling connection between SRNS and SGSN and a signalling connection between SRNS and MSC/VLR for the concerned UE.

2) Security functions may be executed.

3) The 3G_SGSN respective the 3G_MSC/VLR validates the UEs presence. If all checks are successful, then the 3G_SGSN responds to the UE with Routing Area Update Accept and 3G_MSC/VLR responds to the UE with Location Area Update Accept.

4) When the periodic registration procedure is finished, the 3G_SGSN respective the 3G_MSC/VLR may release the signalling connection towards the SRNS for the concerned UE. If both CN noded releases the signalling connection towards the SRNS for the concerned UE, then the SRNS will release the RRC connection towards the UE.

1.3.4.4 Signalling procedures

The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation. In these examples MSC stands for 3G_MSC/VLR and SGSN stands for 3G_SGSN.

Furthermore the list of parameters may not be complete, but should only be seen as examples of possible information carried by the messages.

1.3.4.4.1 SRNS relocation (UE connected to a single CN node, 3G_MSC/VLR) followed by Location Registration in new Routing Area

This example shows SRNS relocation when source RNC and target RNC are connected to different 3G_MSC/VLR. This is then followed by a Routing Area update procedure towards a new SGSN. Figures 1 and 2 illustrate the situation

before respective after the SRNS relocation and location registration. Figure 3 illustrate the signalling sequence where each step is explained in the following list.
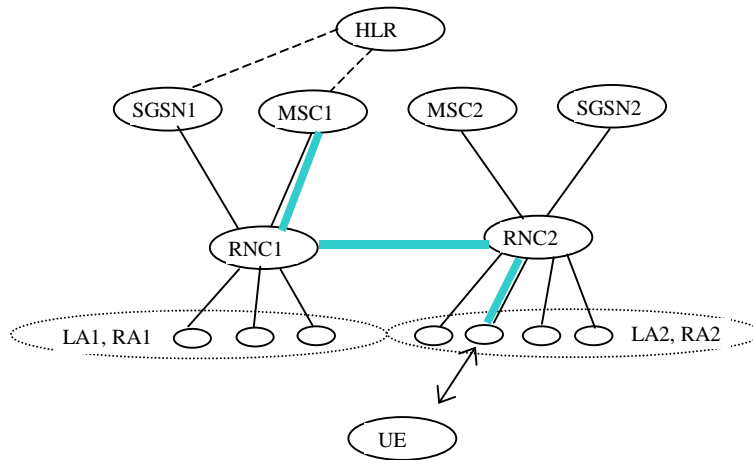

Figure 124: Before the SRNS relocation and location registration

Before the SRNS relocation and location registration the UE is registered in SGSN1 and in MSC1. The UE is in state MM idle towards the SGSN1 and in state MM connected towards the MSC1. The RNC1 is acting as SRNC and the RNC2 is acting as DRNC.
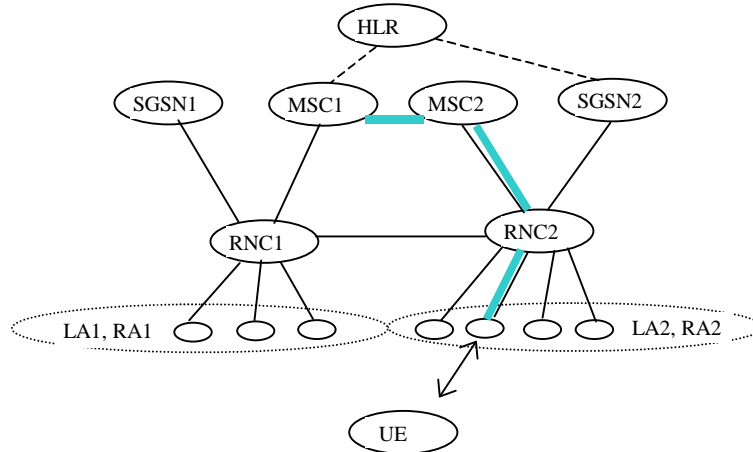

Figure 125: After the SRNS relocation and location registration

After the SRNS relocation and location registration the UE is still registered in MSC1 while the registration in the IP domain has changed from SGSN1 to SGSN2. The UE is in state MM idle towards the SGSN2 and in state MM connected towards the MSC1. The RNC2 is acting as SRNC.
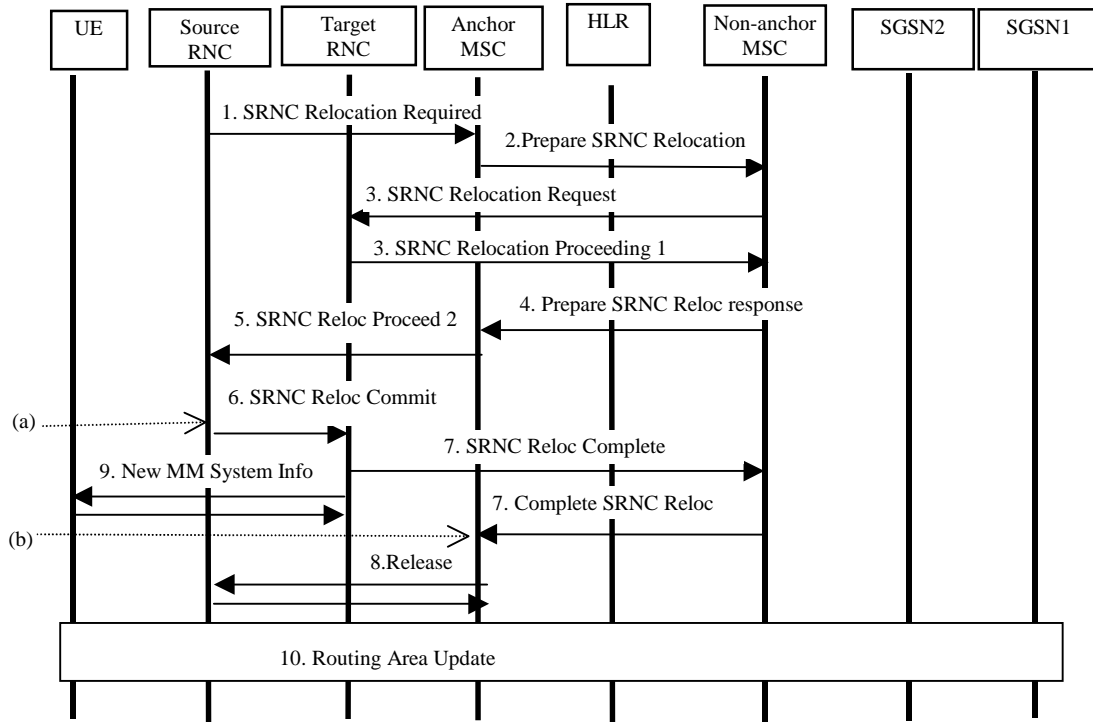
Figure 126: Interface information transfer for SRNS relocation when UE connected to 3G_MSC/VLR followed by location registration in new Routing Area.

1) UTRAN makes the decision to perform the Serving RNC relocation procedure. This includes decision on into which RNC (Target RNC) the Serving RNC functionality is to be relocated. The source SRNC sends SRNC Relocation required messages to the MSC. This message includes parameters such as target RNC identifier and an information field that shall be passed transparently to the target RNC.

2) Upon reception of SRNC Relocation required message the Anchor MSC (MSC1) prepares itself for the switch and determines from the received information that the SRNC relocation will (in this case) involve another MSC. The Anchor MSC will then send a Prepare SRNC Relocation Request to the applicable non-anchor MSC (MSC2) including the information received from the Source RNC.

3) The non-anchor MSC will send a SRNC Relocation Request message to the target RNC. This message includes information for building up the SRNC context, transparently sent from Source RNC (UE id., no of connected CN nodes, UE capability information), and directives for setting up Iu user plane transport bearers. When Iu user plane transport bearers have been established, and target RNC has completed its preparation phase, SRNC Relocation Proceeding 1 message is sent to the non-anchor MSC.

4) The Prepare SRNC Relocation Response that is sent from non-anchor MSC to Anchor MSC will contain the SRNC Relocation Proceeding 1 received from target RNC.

5) When the SRNC Relocation Proceeding 1 has been received in the Anchor MSC, the user plane transport bearers has been allocated the whole path between target RNC and Anchor MSC and the Anchor MSC is ready for the SRNC move, then the Anchor MSC indicates the completion of preparation phase at the CN side for the SRNC relocation by sending the SRNC relocation proceeding 2 message to the Source RNC.

6) When the source RNC has received the SRNC Relocation Proceeding 2 message, the source RNC sends a SRNC Relocation Commit message to the target RNC. The target RNC executes switch for all bearers at the earliest suitable time instance.

7) Immediately after a successful switch at RNC, target RNC (=SRNC) sends SRNC Relocation Complete message to the non-anchor MSC. This message is included by the non-anchor MSC in the Complete SRNC relocation message that is sent to the anchor MSC. Upon reception of this message, the Anchor-MSC switches from the old Iu transport bearers to the new ones.

8) After a successful switch at the Anchor MSC, a release indication is sent towards the Source RNC. This will imply release of all UTRAN resources that were related to this UE.

9) When the target RNC is acting as SRNC, it will send New MM System Information to the UE indicating e.g. relevant Routing Area and Location Area. Additional RRC information may then also be sent to the UE, e.g. new RNTI identity.

10) When receiving new MM system information indicating a new Routing Area, the UE will in this case initiate a Routing Area update procedure towards the SGSN.

Before point (a), in figure 3, the connection is established between UE and Anchor MSC via Source RNC.

After point (b), in figure 3, the connection is established between UE and Anchor MSC via Target RNC and Non-anchor MSC.

1.3.4.4.2 SRNS relocation (UE connected to a single CN node, 3G_SGSN) followed by Location Registration in new Location Area

This example shows SRNS relocation when source RNC and target RNC are connected to different 3G_SGSN. Figures 4 and 5 illustrate the situation before respective after the SRNS relocation and location registration. Figure 6 illustrate the signalling sequence where each step is explained in the following list.
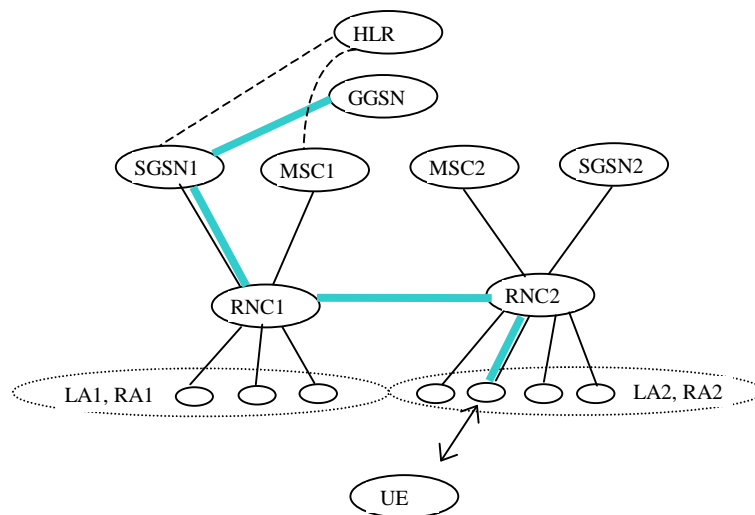

Figure 127: Before the SRNS relocation and location registration

Before the SRNS relocation and location registration the UE is registered in SGSN1 and in MSC1. The UE is in state MM connected towards the SGSN1 and in state MM idle towards the MSC1. The RNC1 is acting as SRNC and the RNC2 is acting as DRNC.
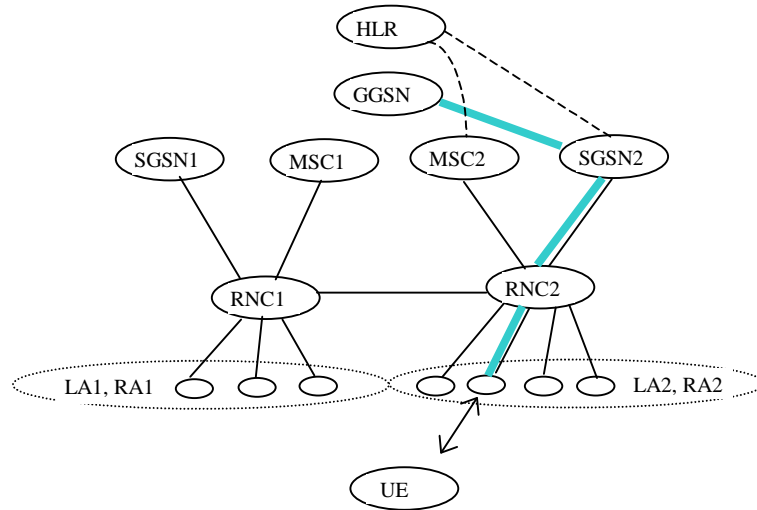
Figure 128: After the SRNS relocation and location registration

After the SRNS relocation and location registration the UE is registered in MSC2 and in SGSN2. The UE is in state MM connected towards the SGSN2 and in state MM idle towards the MSC2. The RNC2 is acting as SRNC.
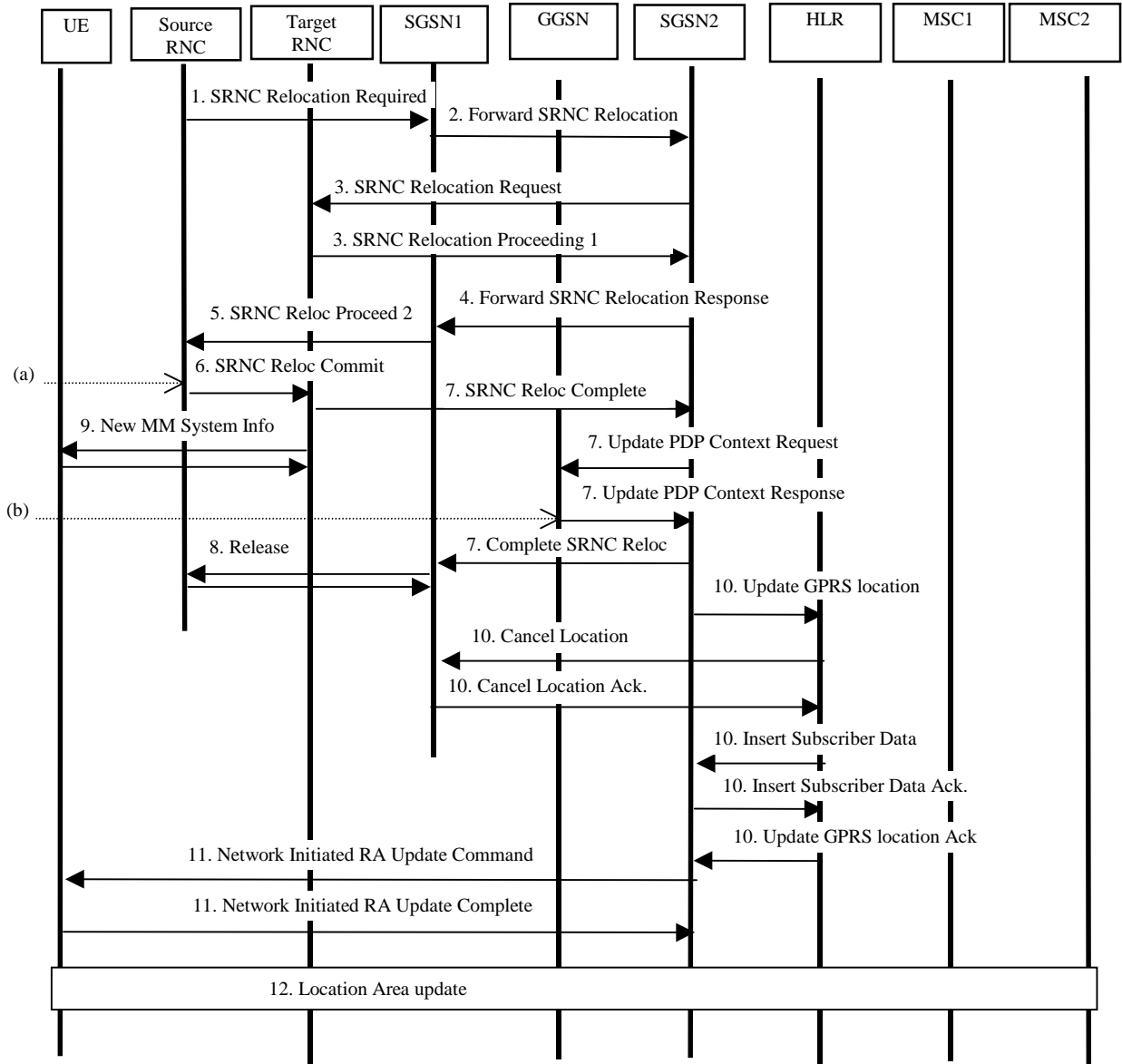
Figure 129: Interface information transfer for SRNS relocation update when changing SGSN area resulting in a change of registered location and followed by location registration in new Location Area.

1)   UTRAN makes the decision to perform the Serving RNC relocation procedure. This includes decision on into which RNC (Target RNC) the Serving RNC functionality is to be relocated. The source SRNC sends SRNC Relocation required messages to the SGSN1. This message includes parameters such as target RNC identifier and an information field that shall be passed transparently to the target RNC.

2)   Upon reception of SRNC Relocation required message the SGSN1 determines from the received information that the SRNC relocation will (in this case) result in change of SGSN.
       The SGSN will then send a Forward SRNC relocation request to the applicable SGSN, SGSN2, including the information received from the Source RNC and necessary information for the change of SGSN (e.g. MM context, PDP context).

3)   The SGSN2 will send a SRNC Relocation Request message to the target RNC. This message includes information for building up the SRNC context, transparently sent from Source RNC (e.g. UE id., no of connected CN nodes, UE capability information), and directives for setting up Iu user plane transport bearers.
       When the Iu user plane transport bearers have been established, and target RNC completed its preparation phase, SRNC Relocation Proceeding 1 message is sent to the SGSN2.

4) When the traffic resources between target RNC and SGSN2 has been allocated and the SGSN2 is ready for the SRNC move, then the Forward SRNC Relocation Response is sent from SGSN2 to SGSN1. This message indicates that necessary resources have been allocated for the SRNC relocation.

5) When the Forward SRNC Relocation Response has been received in the SGSN1, the SGSN1 indicates the completion of preparation phase at the CN side for the SRNC relocation by sending the SRNC Relocation Proceeding 2 message to the Source RNC.

6) When the source RNC has received the SRNC Relocation Proceeding 2 message, the source RNC sends a SRNC Relocation Commit message to the target RNC. The target RNC executes switch for all bearers at the earliest suitable time instance.

7) Immediately after a successful switch at RNC, target RNC (=SRNC) sends SRNC Relocation Complete message to the SGSN2. Upon reception of this message, the SGSN2 updates the GGSN with a Update PDP Context Request including the new SGSN address. The GGSN will then update the PDP context and return Update PDP Context Response. The SGSN will also send a Complete SRNC Relocation towards the SGSN1.

8) At reception of the Complete SRNC Relocation, SGSN1 will send a release indication towards the Source RNC. This will imply release of all UTRAN resources that were related to this UE.

9) When the target RNC is acting as SRNC, it will send New MM System Information to the UE indicating e.g. relevant Routing Area and Location Area. Additional RRC information may then also be sent to the UE, e.g. new RNTI identity.

10) The SGSN2 informs the HLR of the change of SGSN by sending Update GPRS location (IMSI, new SGSN address etc.) to the HLR. The HLR cancels the context in the old SGSN, SGSN1, by sending Cancel Location (IMSI). The SGSN1 removes the context and acknowledges with Cancel Location Ack. The HLR sends Insert subscriber data (IMSI, subscription data) to the SGSN2. The SGSN2 acknowledges with Insert Subscriber Data Ack. The HLR acknowledges the Update GPRS location by sending Update GPRS Location Ack to the SGSN2.

11) At reception of Insert subscriber data from HLR, the SGSN2 will initiate the update of MM information stored in the UE. This is done by sending Network Initiated Routing Area Update Command to the UE. This message will include new RAI, and possible also new P-TMSI. When the UE has made necessary updates it answers with Network Initiated Routing Area Update Complete.

12) When receiving new MM system information indicating a new Location Area, the UE will, in this case, initiate a Location Area update procedure towards the MSC2. This implies that the Location Area update will be performed in parallel to the above indicated activities related to the SGSN side of the Core Network.

Before point (a), in figure 6, the connection is established between UE and GGSN via Source RNC and SGSN1.

After point (b), in figure 6, the connection is established between UE and GGSN via Target RNC and SGSN2.1.3.4.5 Comparision between UMTS and GSM

For the PSTN/ISDN domain, the proposed UMTS MM concept is in principle identical to the GSM MM.

For the IP domain, the differences between the proposed UMTS MM concept and the GSM GMM are more extensive, such as:

a) "Cell update" is moved from GMM level in GSM to RRC level in UMTS.

b) "Routing area update" in GSM GMM-standby state is moved from GMM level in GSM to RRC level in UMTS and corresponds to "URA update".

c) A new case when "Routing area update" is performed towards 3G_SGSN is introduced in the UMTS MM-IDLE state.

d) A UMTS MM-CONNECTED state is introduced and in this state the UE mobility towards the CN will be handled by UTRAN-CN procedures, i.e. not on MM level.

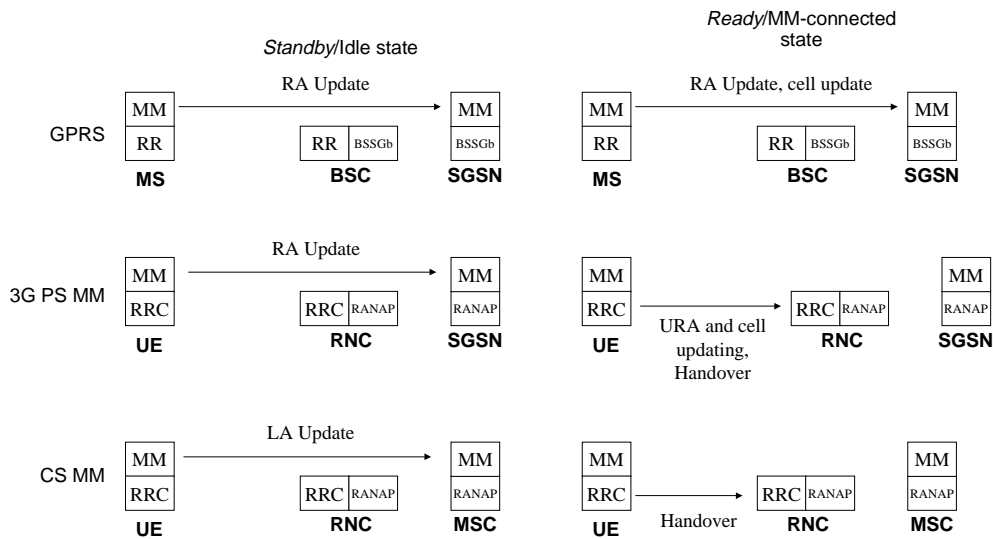Figure 130 provides illustration of the above bullets.

Figure 130. The states written in italics correspond to those defined in GSM with GPRS.

1.3.4.5.1   PS MM-idle state

The RA update procedure is utilized to update the whereabouts of the UE into SGSN. The updating into SGSN takes place irrespectively of the CS MM state in MSC.

1.3.4.5.2   PS MM-connected state

The URA and cell updating and handover procedures presented in Figure 130 are based on UMTS YY.03 [2]. In brief, the aim in [2] is to introduce functionality that caters for the same functionality as standby/ready in GPRS. The RRC shall be designed in such a fashion, which allows the state of the RRC connection to define the level of activity associated to a packet data connection. The key parameters of each state are the required activity and resources within the state and the required signalling prior to the packet transmission. The similar functionality in GPRS is offered via standby/ready at MM level.

The cell update and URA update between UE and RNC are used when the UE is in RRC common channel state, i.e., when the above mentioned parameters allow to scale down the resources reserved for the UE (for a more detailed description on this, see [2]). For example, the purpose of the cell update procedure is to allow the UE to inform its current location in the corresponding RRC state. According to [2] the cell update procedure replaces handover in the corresponding RRC substate.

To summarize, the RRC procedures proposed by [2] allow the CN MM to be independent of the actual activity. This is a significant deviation from GPRS MM, which is closely related to the activity in terms of implementing standby and ready functionality at MM level. Another significant deviation from GPRS is the introduction of the handover procedures for connections supporting traffic into IP domain (in RRC cell connected state, see [2]).

Requirements on Identifiers for UMTS and GSM

1a) The format of the UMTS Location Area Identifier and UMTS TMSI shall not prevent a dual mode GSM-UMTS mobile which was last location updated over the GSM radio interface (ie has a GSM LAI and GSM TMSI), from performing a location update (or other signalling) over the UMTS radio interface to a UMTS MSC.

1b) The format of the UMTS Location Area Identifier and UMTS TMSI shall not prevent a dual mode GSM-UMTS mobile which was last location updated over the UMTS radio interface (ie has a UMTS LAI and UMTS TMSI), from performing a location update (or other signalling) over the GSM radio interface to a GSM MSC.

1c) The format of the UMTS Routing Area Identifier and UMTS P-TMSI shall not prevent a dual mode GSM-UMTS mobile which was last routing area updated over the GSM radio interface (ie has a GSM RAI and GSM P-TMSI), from performing a routeing area update (or other signalling) over the UMTS radio interface to a UMTS SGSN.

1d) The format of the UMTS Routing Area Identifier and UMTS P-TMSI shall not prevent a dual mode GSM-UMTS mobile which was last routing area updated over the UMTS radio interface (ie has a UMTS RAI and UMTS P-TMSI), from performing a routeing area update (or other signalling) over the GSM radio interface to a GSM SGSN.

2) The standard shall support means by which an operator can configure GSM and UMTS cells to be members of the same registration area (ie the mobile can receive paging from whichever cell it is camped on and does not need to location update (or routing update) just because the mobile has changed from a UMTS to a GSM cell).

3a) The standard shall support means by which an operator can allocate GSM and UMTS LAIs which enable GSM MSCs to be able to contact UMTS MSCs and vice versa.

3b) The standard shall support means by which an operator can allocate GSM and UMTS RAIs which enable GSM SGSNs to be able to contact UMTS SGSNs and vice versa.

4) The standard shall support means by which an operator can ensure that the IMSI does not need to be sent over the radio interface when the mobile station moves from a GSM cell to a UMTS cell (and vice-versa).

5) The standard shall support means by which an operator can ensure that the IMSI does not need to be sent over the radio interface when a USIM is moved from a UMTS mobile station to a GSM mobile station (and vice-versa).

6) The standard need not support means by which an operator can ensure that the IMSI is not sent over the radio interface when a GSM SIM is moved from a GSM mobile station to a UMTS mobile station (and vice-versa).

1.3.4.6 Issues for further study

List of issues that are for further study related to this capter was collected during the SMG12 Castle Coombe meeting and is the following:

a) More details are required with regards to the differences with regards to the "IP-domain" MM compared to GPRS MM, especially considering roaming and handover to/from UMTS to GSM/GPRS.

b) Connections between the different areas: Whether all the restrictions listed should apply for UMTS or not is ffs. Consideration should be taken to the need for GSM compatibility and possibilities for further evolution of the solution in UMTS phase 1 and future phases.

c) More details are required with regards to the "UTRAN with distribution functionality" as outlined in Figure 1. Considerations should also be taken in order for UTRAN to be connected to other core network nodes than what has been described in the proposal.

d) More details should be provided with regards to the logical relations between UE-CN and UTRAN-CN, and how these relate to the physical interconnection between UTRAN and the CN nodes(s), namely whether one logical/physical Iu can be used to interconnect the UTRAN with the CN.

e) It should be clarified whether this approach allows for the possibility to use a common signalling connection from MSC and/or SGSN to the HLR.

1.3.5 One MM Concept

1.3.5.1 Impacts and benefit of the single MM approach

1.3.5.1.1 Radio resource

The use of the dual MM approach of contemporary GSM/GPRS has had impacts upon the radio resource due to the requirements to operate disparate mechanisms for circuit and packet modes (CS/PS). The development of UMTS is a good opportunity to optimise the use of the scarce radio resource, one method of minimising the radio resource load is to operate a combined or single MM approach. This approach should be developed to build upon techniques developed

(

for GSM/GPRS to utilise a single MM instance (the Gs interface). The single MM approach will provide an optimised use of the radio resource when compared to the two MM approach.

1.3.5.1.2 Network signalling load

Within the current GSM/GPRS architecture the use of two MM instances machines within the MSC/SGSN leads to multiple interactions between the MSC/SGSN and HLR for mobility purposes (see SMG 12 T Doc C-99-021 for information on multiple updates for VLR and SGSN area change). This impacts upon the signalling between the Home and Visited Networks. UMTS should provide the capability to reduce this 'dual' signalling impact, concepts such as the GLR should be developed and adopted to minimise this signalling impact.

One option to provide this could be the use of a local 'master' cache of data within the visited network to hold common user subscriber data, security/cipher information and be the common point for the 'single MM'. This 'cache' could be functionally located within either the SGSN or the VMSC (or a single CN node). Signalling interactions will need to be developed between nodes if separate CN nodal functionality (i.e. SGSN / VMSC) is envisaged.

The use of concepts such as the GLR and the 'Super Charger' and the relationship with the signalling load between the home and the visited networks, (from the single common MM) should also be considered.

1.3.5.1.3 Location and routing areas

If operators wish they could just utilise the GPRS location management scheme, relying upon Routing Area updates mapped on to the VLR to notify the network of the mobile's location. This means that UMTS operators do not need to operate both GSM MSCs and GPRS GSNs for UMTS, it just means that a single (GPRS like) mechanism will be used for mobility management. If required the Routing Area can be configured to the size of a Location Area, or may be reduced in size, however two disconnected schemes will not operate in parallel (for example from the network based Insert Subscriber Data and security perspectives). Multi-layer location management techniques should also be considered, especially when considering regional/zonal type features such as Solsa and opportunities for private base stations (CTS).

1.3.5.2 One MM Concept Procedures

Given below is only one possible implementation for the idle mode procedures when there is no context in the UTRAN. These procedures require the set up an RRC connection for the duration of the procedure. The procedures over the air are almost the same as defined in GSM/GPRS release 98. The example chosen is for combined procedures of a UE moving from 2 CN element to a UMSC controlled UTRAN area. Other solutions might exist and may be used if found more suitable. Signalling procedures do not represent the complete set of possibilities and these sequences are merely examples of a typical implementation. Further more, the list of parameters may not be complete but should only be seen as examples of possible information carried by the messages. The network architecture considered is given in Figure:1.
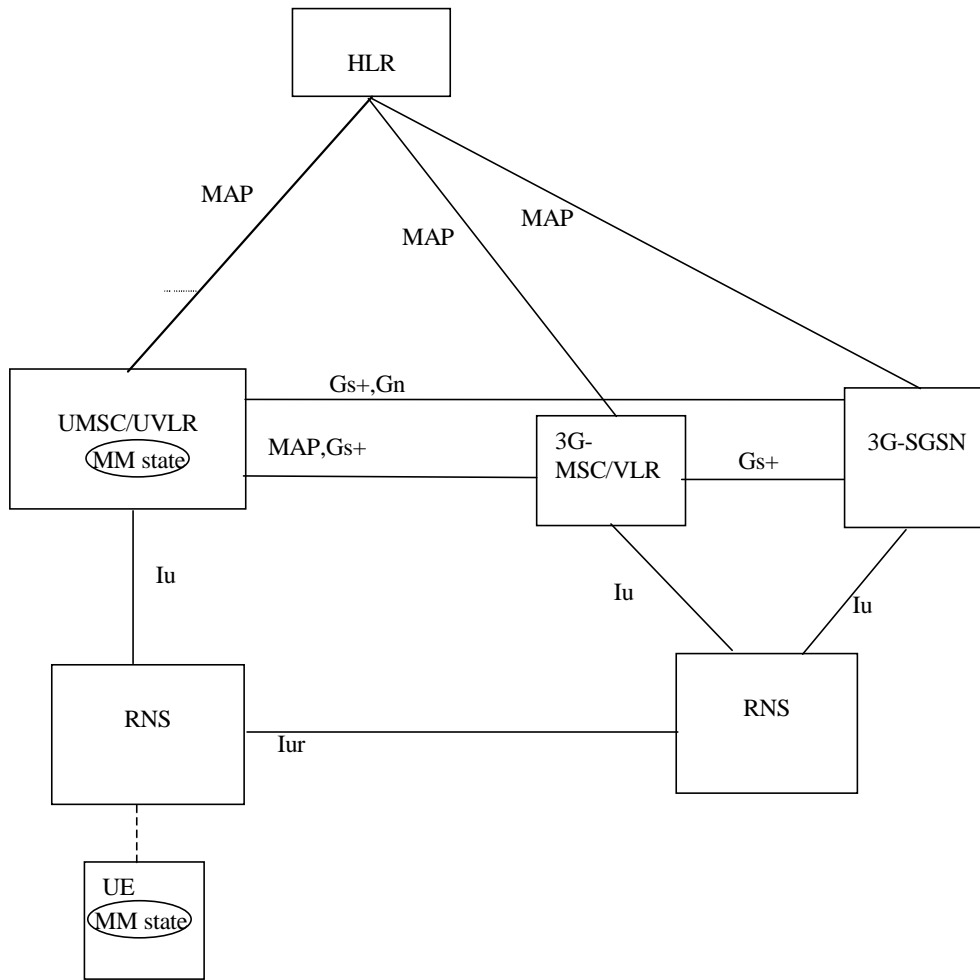
Figure 132: Network architecture considered

1.3.5.3 Support of 2 CN elements

In a homogenous UMTS network with only one CN element, combined LA/RA updates are not necessary. Instead the UE can be tracked to the finer granularity required depending on the type of attach. Similarly, one temporary identifier would have sufficed.

However, to support inter-working with the 2 CN element world, these have to be modified in order to avoid two network modes of operation by the UE. (Note that the UTRAN may still need two modes depending on the CN type to which it is attached; for e.g., for SRNS relocation procedure.) When there is a change in LA/RA the UE has to use the combined procedures. Two temporary identifiers should be issued for combined attach.

1.3.5.4 Use of CN discriminator

 In line with GSM release 98 standard, the combined procedures should be sent with the CN discriminator directed towards the SGSN. Messages for CS or PS case can be directed with CN discriminator to 3G-MSC and 3G-SGSN respectively. Note that messages sent to the UMSC do not need the use of the CN discriminator but it is used here only for support of 2 CN elements.

1.3.5.5 Temporary identifiers

Separate temporary identifiers for CS and PS attach are used to allow inter-working between two possible cases. Thus two identifiers will be issued by the UMSC namely TMSI for CS and P-TMSI for PS attach. Note that both the identifiers will be carried by the same message to the UE as in the combined procedure used in GSM/GPRS.

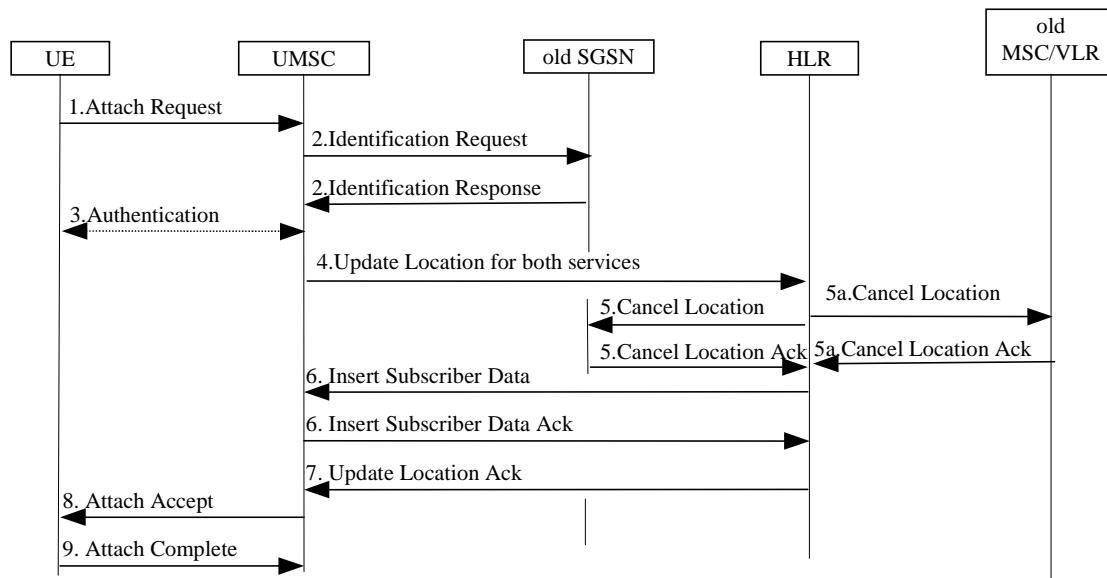## 1.3.5.6 Combined attach case where the previous attach was towards 2 CN elements

Figure 133: Combined attach procedure when the Ms moves froom 2 CN element to a UMSC

1) The UE initiates the attach procedure by the transmission of an Attach Request (IMSI or P-TMSI and old RAI, Attach Type, old P-TMSI Signature) message to the UMSC. Attach Type indicates which type of attach that is to be performed, i.e., PS attach only, CS attach only, or combined attach (the example given is for combined attach).

2) If the UE identifies itself with P-TMSI and the 3G-SGSN/UMSC has changed since detach, the new UMSC sends an Identification Request (P-TMSI, old RAI, old P-TMSI Signature) to the old SGSN to request the IMSI. The old SGSN responds with Identification Response (IMSI, Authentication Triplets). If the UE is not known in the old SGSN, the old SGSN responds with an appropriate error cause. The old SGSN also validates the old P-TMSI Signature and responds with an appropriate error cause if it does not match the value stored in the old SGSN.

3) The authentication functions are optional and may be used for example if P-TMSI signature authentication was not successful.If the UMSC number has changed since the detach, or if it is the very first attach, routeing/location area update procedures are executed:

4) The UMSC sends a Combined Update Location (UMSC Number, UMSC Address, IMSI) to the HLR.

5) The HLR sends Cancel Location (IMSI, Cancellation Type) to the old SGSN and MSC. The old SGSN and MSC acknowledges with Cancel Location Ack (IMSI).

6) The HLR sends Insert Subscriber Data (IMSI, PS and CS subscription data) to the new UMSC. The new UMSC validates the UE's presence in the (new) RA. If all checks are successful then the UMSC constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

7) The HLR acknowledges the Update Location message by sending an Update Location Ack to the UMSC. If the Update Location is rejected by the HLR, the UMSC rejects the Attach Request from the UE with an appropriate cause.

8) The UMSC sends an Attach Accept (P-TMSI, TMSI, P-TMSI Signature) to the UE.

9) If P-TMSI or TMSI was changed, the UE acknowledges the received TMSI(s) with Attach Complete (P-TMSI, TMSI).

If the Attach Request cannot be accepted, the UMSC returns an Attach Reject (IMSI, Cause) message to the UE.

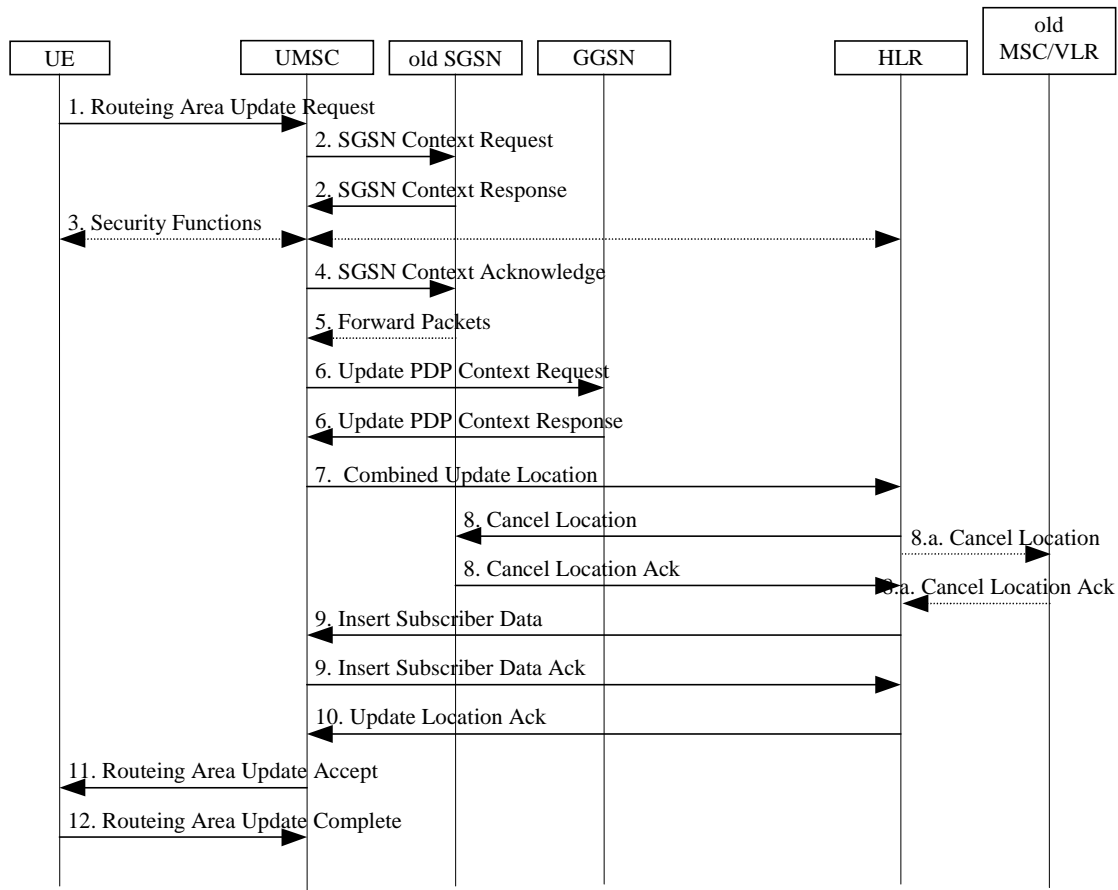## 1.3.5.7 Combined location/routing area update where the previous LA/RA belonged to a 2 CN element

Figure 134: Combined LA/RA update when the MS moves from 2 CN element to UMSC

1) The UE sends a Routeing Area Update Request (old RAI, old P-TMSI Signature, Update Type) to the new UMSC. Update Type example given here is for combined RA / LA update.

2) The new UMSC sends SGSN Context Request (old RAI, P-TMSI, old P-TMSI Signature, New UMSC Address) to the old SGSN to get the MM and PDP contexts for the UE. The old SGSN validates the old P-TMSI Signature and responds with an appropriate error cause if it does not match the value stored in the old SGSN. This should initiate the security functions in the new UMSC.

3) Security functions may be executed. These procedures are defined in subclause "Security Function".

4) If the user has at least one activated PDP context, then the new UMSC shall send an SGSN Context Acknowledge message to the old SGSN. This informs the old SGSN that the new UMSC is ready to receive data packets belonging to the activated PDP contexts.

5) The old SGSN starts tunnelling of buffered N-PDUs to the new UMSC. However, the possibility of this happening is remote since the UE is in MM-idle indicating that it was not in active communication.

6) The new UMSC sends Update PDP Context Request to the GGSNs concerned. The GGSNs update their PDP context fields and return an Update PDP Context Response (TID).

7) The new UMSC informs the HLR of the change of SGSN/MSC by sending Combined Update Location (UMSC Number, UMSC Address, IMSI) to the HLR.

8) The HLR sends Cancel Location (IMSI, Cancellation Type) to the old SGSN and MSC. The old SGSN acknowledges with Cancel Location Ack (IMSI).

9) The HLR sends Insert Subscriber Data (IMSI, PS and CS subscription data) to the new UMSC. The new UMSC validates the UE's presence in the (new) RA. If due to regional subscription the UE is rejected, the UMSC rejects the Attach Request with an appropriate cause and returns an Insert Subscriber Data Ack (IMSI, UMSC Area Restricted Due To Regional Subscription) message to the HLR. If all checks are successful then the UMSC constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

10) The HLR acknowledges the Update Location by sending Update Location Ack (IMSI) to the new UMSC.

11) The new UMSC validates the UE's presence in the new RA. If due to regional, national or international restrictions the UE is not allowed to attach in the RA or subscription checking fails, then the UMSC rejects the routeing area update with an appropriate cause. If all checks are successful then the new UMSC establishes MM and PDP contexts for the UE. The new UMSC responds to the UE with Routeing Area Update Accept (P-TMSI, TMSI, P-TMSI Signature).

12) The UE confirms the reallocation of the TMSIs by sending Routeing Area Update Complete to the UMSC.
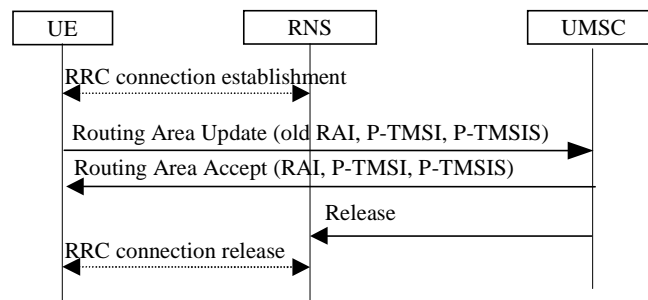
1.3.5.8 Periodic Registration towards UMSC

Figure 135: Periodic update procedure when the MS is attached for both CS and PS services

An RRC connection is established for the periodic registration. Note that this procedure is invoked only when the UE is in MM-idle state. The UE sends a Routing Area Update to the UMSC. The UMSC authenticates the P-TMSI signature. If the update is successful it sends a Routing Area Accept message. The RRC connection is then released.

1.3.5.9 UE initiated Detach Procedure

The UE-Initiated Detach procedure when initiated by the UE is illustrated in Figure 136. Each step is explained in the following list.
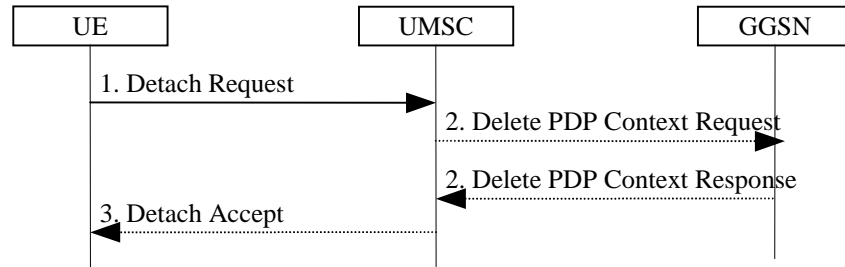

Figure 136: UE-Initiated Combined Detach Procedure

1) The UE detaches by sending Detach Request (Detach Type, Switch Off) to the UMSC. Detach Type indicates which type of detach that is to be performed, i.e., PS Detach only, CS Detach only or combined Detach. Switch Off indicates whether the detach is due to a switch off situation or not.

2) If PS detach, any active PDP contexts in the GGSNs regarding this particular UE may be deactivated. This is FFS

3) If Switch Off indicates that the detach is not due to a switch off situation, the UMSC sends a Detach Accept to the UE.

1.3.5.10 List of MAP services for location management between the HLR and MSC-VLR/SGSN for GSM/GPRS

Table 1 shows the MAP services used for location management between the SGSN and MSC/VLR and the HLR as defined in GSM/GPRS release 98.

MAP service	Comment
MAP_UPDATE_LOCATION service	Updates VLR and MSC number in the HLR
MAP_UPDATE_GPRS_LOCATION service	Updates SGSN number and address in the HLR
MAP-INSERT-SUBSCRIBER-DATA service	Inserts subscriber data for GSM or GPRS
MAP_SEND_AUTHENTICATION_INFO service	To send authentication triplets to VLR or SGSN
MAP_CANCEL_LOCATION service	Cancels location in VLR or SGSN
MAP_PURGE_MS service	Marks user as unreachable in HLR. Common service for both GSM and GPRS

Table 1: List of Location management services between the HLR and MSC/VLR and SGSN

From the above table, it is clear that only minor modifications are required to MAP services between the MSC/VLR and SGSN and the HLR. A new service combining the MAP_UPDATE_LOCATION and MAP_UPDATE_GPRS_LOCATION services will need to be defined. All other services are common for both GSM and GPRS and can be used with minor modifications in the "conditional" parameter list.

1.3.6 Single Mobility Management in the core network for a combined 3G-(MSC/VLR+SGSN) configuration

1.3.6.1 Motivation

In order to optimise the signalling load within the network, reduce operating and maintenance costs and creating the possibility to combine cs and ps handover it is essential to open the door in the specifications for combined 3G-(MSC/VLR+SGSN) solutions.

1.3.6.2 Technical description

For the area concept discussed for the time being, four different cases have to be distinguished:

1. change of UTRAN Registration Area (URA) within the same Routing Area (RA)

2. change of URA and RA within the same Location Area (LA)

3. change of URA, RA, or LA within the same node

4. change of URA, RA, or LA, and node

For a combined 3G-(MSC/VLR+SGSN) node only in case 4 the UE's HLR has to be updated. If the UE is idle mode for the packet and circuit switched traffic a combined 3G-(MSC/VLR+SGSN) node will run the location update procedure jointly for the UE's cs and ps domain resulting in one combined location update message, see Figure 3.
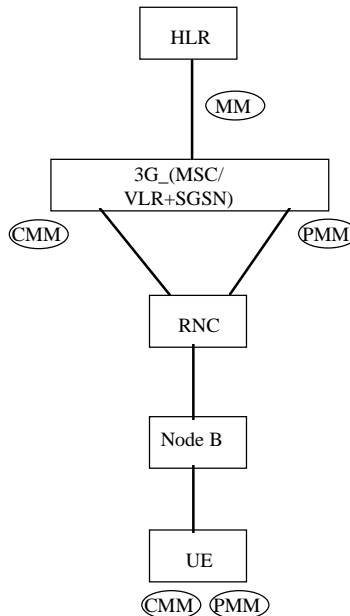

Figure 138: Combined MM Instance For a Combined 3G-(MSC/VLR+SGSN) Node

Split nodes may have to run one specific location update procedure for any of the two domains resulting in two separate location update messages, see Figure 4.
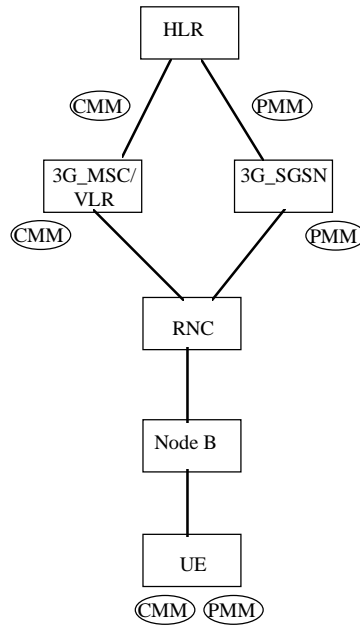
Figure 139: Split MM Instances for Separate Nodes

1.3.6.3 Requirements on UTRAN

The provision of location information by the UE to the core network must be independently of whether the 3G-MSC/VLR and 3G-SGSN are implemented as separate entities or as a combined node. It shall be possible to use a combined update procedure between serving node and HLR irrespective of the update procedure used between the UE and the serving node.

Appendix 3 SRNS Relocation

9.3.4.5   SRNS Relocation with inter MSC Streamlining and inter SGSN RA Update

For a Ue with simultaneous communications in both PSTN/ISDN and IP domains both the MSC and SGSN will be involved for SRNS Relocations.

Figure 1 *(see figure 1 of td 187)* illustrates the CN paths for three SRNS relocations. The mechanism of operation via connection of the UTRAN to a lightly modified GSM/GPRS CN infrastructure (modifications for the Iu and SRNS relocation mechanism: retention of contemporary GSM/GPRS inter MSC handover and inter SGSN RA update procedures) is shown [1: section 9.3.4.4.1 and 9.3.4.4.2 *revise references to reflect section from td 239r1*].

As the mobile moves from right to left, SRNS relocation takes place:

1st SRNS Relocation: RNS A to RNS B

Within the Core Network the anchor MSC concept has been maintained, an additional path between MSC A and MSC B is added, bridging/switching (of the PSTN/ISDN traffic) occurs at MSC A for this (inter MSC) streamlining.

For the GSNs inter SGSN RA update occurs between SGSN A and SGSN B, the GGSN (the 'packet anchor') is also involved. An (network initiated) RA update will be performed after the SRNS relocation. No location update will be performed.

2nd SRNS Relocation: RNS B to RNS C

With the anchor MSC (A) a 'subsequent inter MSC streamlining' is performed between MSC A and MSC 'C' (the path between MSC A and MSC B is released). Again bridging/switching (of the PSTN/ISDN traffic) occurs at MSC A for this (inter MSC) subsequent streamlining.

For the GSNs inter SGSN RA update occurs between SGSN B and SGSN C, the GGSN (packet anchor) is also involved. An (network initiated) RA Update will be performed after the SRNS relocation.   No location area update will be performed.
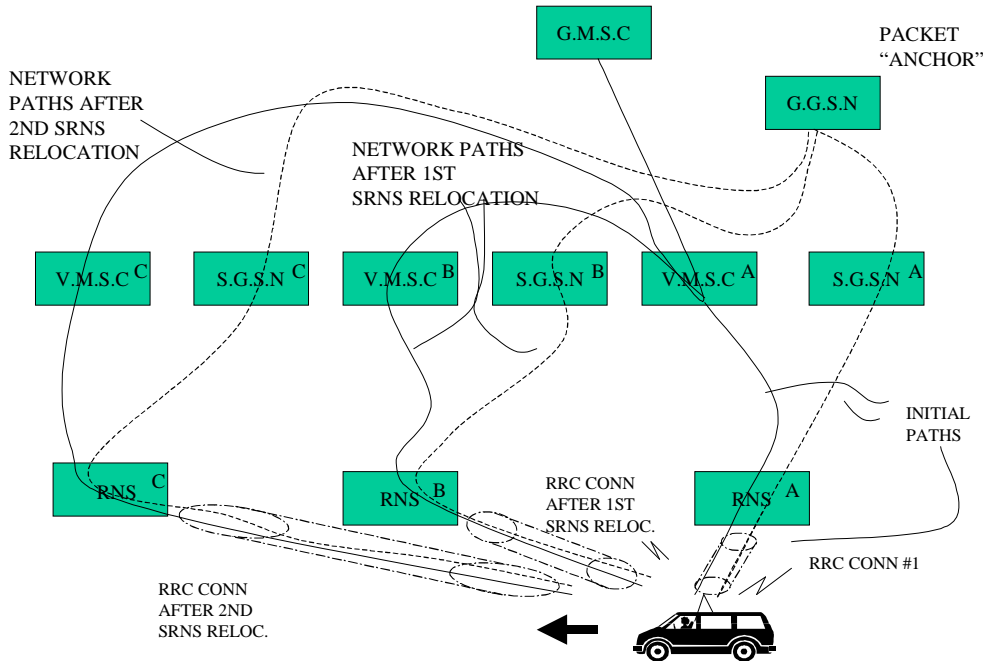
(

Figure *1* SRNS Relocation: Inter MSC streamlining and inter SGSN RA update

9.6.x.y   SRNS Relocation with inter MSC streamlining and 'anchored' inter SGSN RA Update

For a Ue with simultaneous communications in both PSTN/ISDN and IP domains both the MSC and SGSN will be involved for SRNS Relocations, figure 2 illustrates the CN paths for three SRNS relocations and also shows the SGSN anchor concept [section 9.6.x].

As the mobile moves from right to left, SRNS relocation takes place:

1st SRNS Relocation: RNS A to RNS B

For the GSNs the 'anchor SGSN' concept has been incorporated. A new network path is added between SGSN A and SGSN B, SGSN A will connect/bridge this path with the path to the GGSN. It could be assumed that no RA update will be performed by the UE as the SGSN A is acting as the 'anchor point' (a similar concept to the MSC part); this is ffs.

2nd SRNS Relocation: RNS B to RNS C

With the anchor MSC (A) a 'subsequent inter MSC streamlining' is performed between MSC A and MSC 'C' (the path between MSC A and MSC B is released). Again bridging/switching (of the PSTN/ISDN traffic) occurs at MSC A for this (inter MSC) subsequent streamlining.

For the GSNs SGSN A remains the anchor, a new network path is added between SGSN A and SGSN C, SGSN A will connect/bridge this path with the (original) path to the GGSN and will switch between SGSN B to SGSN C upon SRNS relocation. It could be assumed that no RA update will be performed by the UE as the SGSN A is acting as the 'anchor point' (a similar concept to the MSC part); this is ffs.

**FIGURE 2: SRNS RELOCATION WITH INTER MSC STREAMLINING &
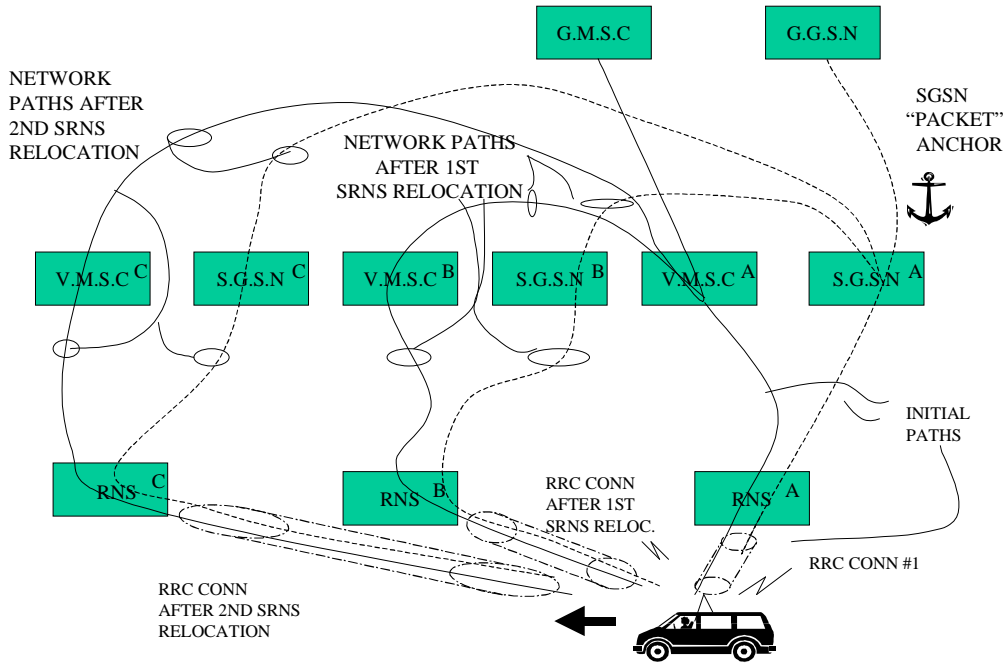"ANCHORED" INTER SGSN RA UPDATE**

Figure *2* SRNS Relocation with Inter MSC streamlining and the 'Anchor SGSN concept '

The impact upon the CN paths with and without the SGSN based anchor can be compared by considering Figures 1 and 2 *link to the figures within the MM section showing the current concepts (relates to the td 239)* respectively.