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Feasibility study for transport and control separation
in the PS CN domain
(3GPP TR 23.873 version 4.0.0 Release 4)

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Foreword

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

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

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Contents

Foreword

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

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

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

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

Editor's note: This feasibility study has been concluded without reaching consensus on which alternative to recommend and consequently none of them is retained for standardisation. This TR is now closed.

1   Scope

The scope of this Technical Report (TR) is to capture the results of a feasibility study on how to introduce a clear separation of transport and control functions in the PS CN domain, with minimum impacts on the reference logical architecture for R'00.

With this separation in view, functional elements of the PS CN domain that provide both significant control and transport functions may be decomposed into two separate functional entities: one entity taking care of the control functionality and an other entity handling the payload transport. An exact distribution of the functions currently supported by a single functional entity between new functional entities and other network entities will be defined as the result of this feasibility study, if necessary.

A standard control protocol should be used between the control and transport entities, if applicable, e.g. H.248. The required functionality, e.g. extensions to H.248 or any other protocol which may be chosen for this task, would have to be defined and standardised within 3GPP. This TR will identify and define these extensions, and extensions to other interfaces if applicable.

More generally, the aim of this TR is to identify and strive to solve all issues introduced by such evolution of the PS CN domain. At the end of the feasibility study, the remaining open issues will be reported and their importance will be assessed. An analysis of the benefits and drawbacks of separating the control and transport functions in the PS CN domain will also be performed.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3G TS 23.060: "General Packet Radio Service (GPRS); Service Description; Stage 2".

[2] 3G TS 23.078: "Customised Applications for Mobile Network Enhanced Logic (CAMEL) Phase 3 – Stage 2".

[3] 3G TR 23.821: "Architecture Principles for Release 2000".

[4] 3G TR 23.923: "Combined GSM and Mobile IP Mobility Handling in UMTS IP CN"

[5] 3G TS 29.060: " General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp Interface".

[6] 3G TS 32.015: "Telecommunications Management; Charging and billing; 3G call and event data for the Packet Switched (PS) domain".

[7] 3G TS 33.107: "3G Security; Lawful Interception Architecture and Functions".

3 Symbols and Abbreviations

3.1 Symbols

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

Mp   Interface between an SGSN server and a PS-MGW.

3.2 Abbreviations

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

cSGSN   Control Serving GPRS Support Node
PS-MGW   Packet Switching Media Gateway
SGSN server   Serving GPRS Support Node server
xGGSN   Extended Gateway GPRS Support Node

4 Introduction

This technical report (TR) was created in order to study a clear separation of transport and control functions in the PS CN domain, with minimum impacts on the reference architecture for R'00. As different approaches can be considered for achieving this goal, the following sections describe and analyse a few alternatives that have been identified as the most viable. The summary will then compare the different alternatives and formulate a conclusion about which alternative is proposed to be adopted for release 2000. This will constitute the base for the decision to be taken by S2.

NOTE: This feasibility study has been concluded without reaching consensus on which alternative to recommend and consequently none of them is retained for standardisation.

5 Reference Logical Architecture

This chapter describes a reference architecture which we use as a basis for the evolved architecture.

The full view of Release 2000 architecture (as specified in 3G TR 23.821) is the reference logical architecture for this TR and is provided in figure 1.
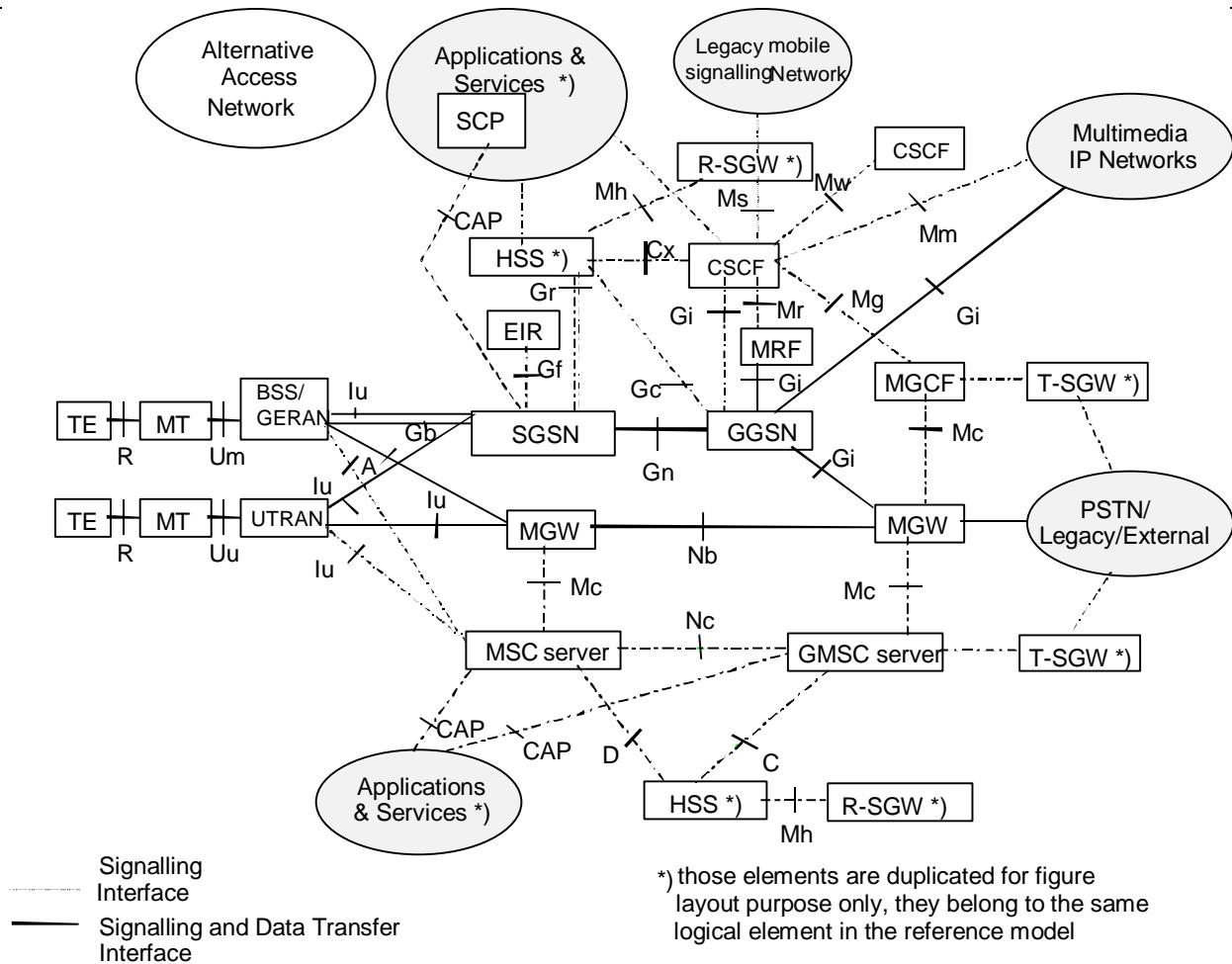
Figure 1: Reference logical architecture

6 Alternative 1: SGSN Server – PS Media Gateway Approach

6.1 Introduction

In the PS CN domain the node that comprises the more user and control plane functions is undoubtedly the SGSN. It is therefore judicious to consider the SGSN as the primary target for a split of its user and control plane functions.

This approach consists in decomposing the SGSN into an SGSN server and a PS media gateway (PS-MGW). The SGSN server handles all the signalling interfaces (Gs, Gr, Gd, etc) as well as the GTP-C protocol, whereas the PS-MGW handles the user traffic, in particular the GTP-U protocol.

With this approach, the total load solely supported by the SGSN in the R'99 architecture is distributed over two different network elements. The dynamic allocation of PS-MGW resources should lead to an increase in the ability to better utilise the total network capacity.

The functional allocation between SGSN server and PS-MGW can be summarised as follows.

Functions of the SGSN server:

- Session Management

- Mobility Management

- GTP-C termination

- MAP termination

- RANAP termination

- CDR handling

- Provision of Intercept Related Information (Lawful Interception)

- Media gateway management (registration, selection)

- CAP termination

- PS Media Gateway Control

- etc.

Functions of the PS-MGW:

- GTP-U termination

- Quality of Service Provision

- Collection of data for charging or detection of data threshold if required

- Reporting of data on demand or event to the SGSN server

- Provision of Content of Communications (Lawful Interception)

- Iu release procedure support (packet buffering, indication to SGSN server)

- etc.

The SGSN server controls the PS-MGW through the Mp interface and the GGSN through the Gn interface by means of GTP-C messages. GTP-U packets are transferred between the PS-MGW and the GGSN over the Gn interface, and between the PS-MGW and the RNC over the Iu interface, following the GTP-U specification.

The SGSN server supports only the Iu interface. When the Gb interface has to be supported (GSM/GERAN access), a 2G-SGSN is required. It is then an implementation/operator option whether both Gb and Iu interfaces are supported in the same physical node, by combining the SGSN server and 2G-SGSN, or whether the Gb interface is supported exclusively through a 2G-SGSN. For a 2G-SGSN the Gn interface supports both user and control data.

The functional impacts of the decomposition into an SGSN server and PS-MGW are confined to the SGSN itself and hence neither RNCs, GGSNs or other SGSNs, nor the protocols used between these nodes are impacted. Besides the Mp interface between SGSN server and PS-MGW, no other interfaces are impacted by this proposal.

6.2 Logical Architecture

The logical architecture for this approach, as an evolution of the reference logical architecture, is depicted in figure 2.
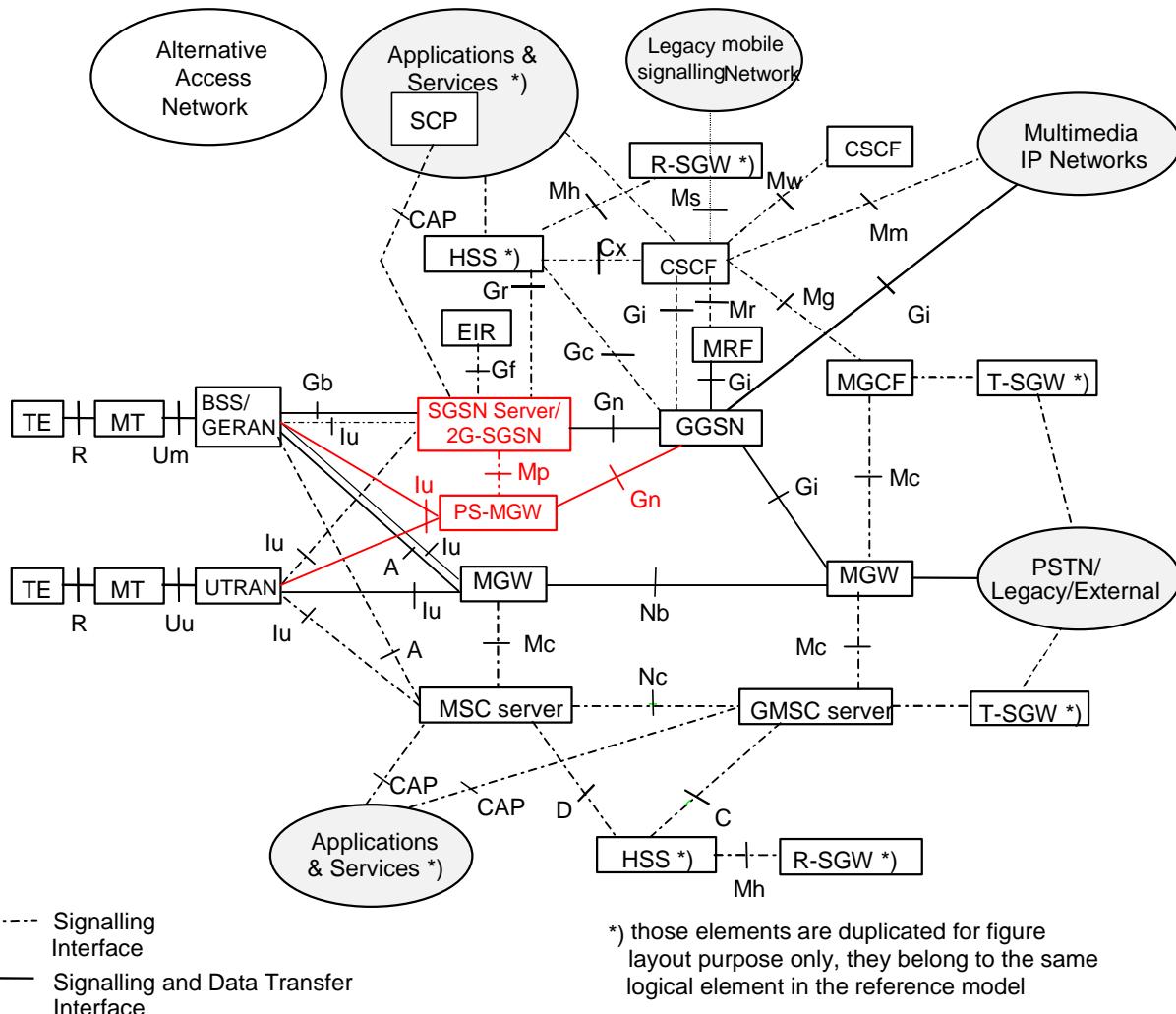
Figure 2: Evolved logical architecture with SGSN server and PS-MGW

NOTE: Putting SGSN server and 2G-SGSN in the same node is an implementation option.

6.2.1 Functional Nodes

6.2.1.1 SGSN Server

The SGSN server is the main control node for GPRS. It handles all the signalling interfaces of an SGSN, including the GTP-C protocol on the Gn and Gp interfaces and the RANAP protocol on the Iu interface. The SGSN server controls the PS Media Gateway (PS-MGW) through the Mp interface.

6.2.1.2 2G-SGSN

This evolved architecture has no impact on the 2G-SGSN. A 2G-SGSN is necessary to support the Gb interface. The Gn interface of a 2G-SGSN supports both user and control data.

6.2.1.3 PS Media Gateway (PS-MGW)

The PS-MGW handles the user plane for GPRS. It terminates the GTP-U tunnels towards the GGSN over the Gn and Gp interfaces and towards the RNC over the Iu interface.

The relation between the SGSN server and the PS-MGW represents the architectural association between a master and a slave, respectively. Therefore, this association implies that the Mp interface is a master-slave interface.

6.2.2 Interfaces

Only interfaces for which some clarification is felt useful are mentioned in this section. Interfaces that are not described here conform to their definition in the relevant specifications.

The protocols GTP-U, GTP-C, RANAP and BSSGP referred to in the following subclauses conform to their current specifications and are not impacted by the decomposition of the SGSN.

6.2.2.1 SGSN server – PS-MGW (Mp) (Iu Mode Only)

The PS-MGW is controlled by the SGSN server through the Mp interface.

6.2.2.2 UTRAN – SGSN server (Iu) (Iu Mode Only)

The Iu interface between the RNC and the SGSN server supports the RANAP protocol.

6.2.2.3 UTRAN – PS-MGW (Iu) (Iu Mode Only)

The Iu interface between the RNC and the PS-MGW supports the GTP-U protocol.

6.2.2.4 BSS – 2G-SGSN (Gb) (Gb Mode Only)

The Gb interface between the BSS and the 2G-SGSN supports the BSSGP protocol. This interface belongs to both to the user and control planes.

6.2.2.5 2G-SGSN/SGSN server – GGSN (Gn, Gp)

In Iu mode, the Gn interface between the SGSN server and the GGSN supports the GTP-C protocol.

In Gb mode, the interface between the 2G-SGSN and the GGSN supports the GTP-C protocol in the control plane and the GTP-U protocol in the user plane.

The Gp interface provides the same functionality as the Gn interface, except that it applies only when the 2G-SGSN/SGSN server and the GGSN belong to different PLMNs.

6.2.2.6 PS-MGW – GGSN (Gn) (Iu Mode Only)

The Gn interface between the PS-MGW and the GGSN supports the GTP-U protocol.

6.2.2.7 Gn interface for inter SGSN procedures

At inter SGSN intersystem change (UMTS to/from GSM):

- the Gn interface between the SGSN server and the 2G-SGSN supports the GTP-C protocol.

- the Gn interface between the 2G-SGSN and the PS-MGW controlled by the peer SGSN server supports the GTP-U protocol.

When the MS moves between GSM cells served by two different 2G-SGSNs:

- the Gn interface between 2G-SGSNs supports both the GTP-C and GTP-U protocols.

When the MS moves between UMTS cells served by two different SGSN servers:

- the Gn interface between SGSN servers supports the GTP-C protocol.

6.2.3 User plane

The protocol stack for the user plane is shown in figure 3.
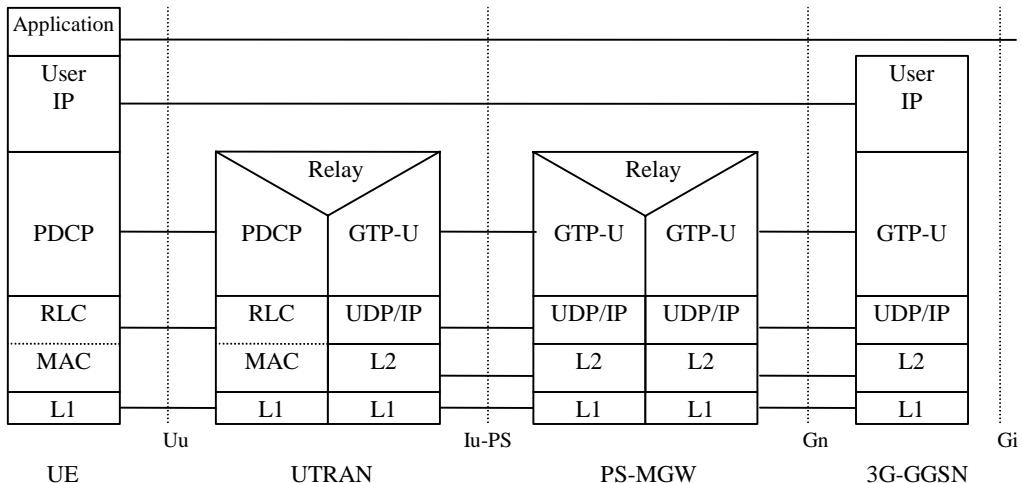
Figure 3: User plane protocol stack

6.3 H.248 option over Mp

NOTE: Two options are considered in this TR as to the protocol to use over the Mp interface; H.248 with extensions and GTP-C with extensions. Both options are described for comparison purposes, however only one of them shall eventually be retained. The protocol selection might be deferred to the stage 3 work.

6.3.1 Mobility Management (H.248 option)

6.3.1.1 Detach Procedures

The detach procedure can be initiated by the MS, by the SGSN and by the HLR. The latter two sequences are omitted in this description as they are similar to the first sequence, and they do not add any complexity to the detach sequences.
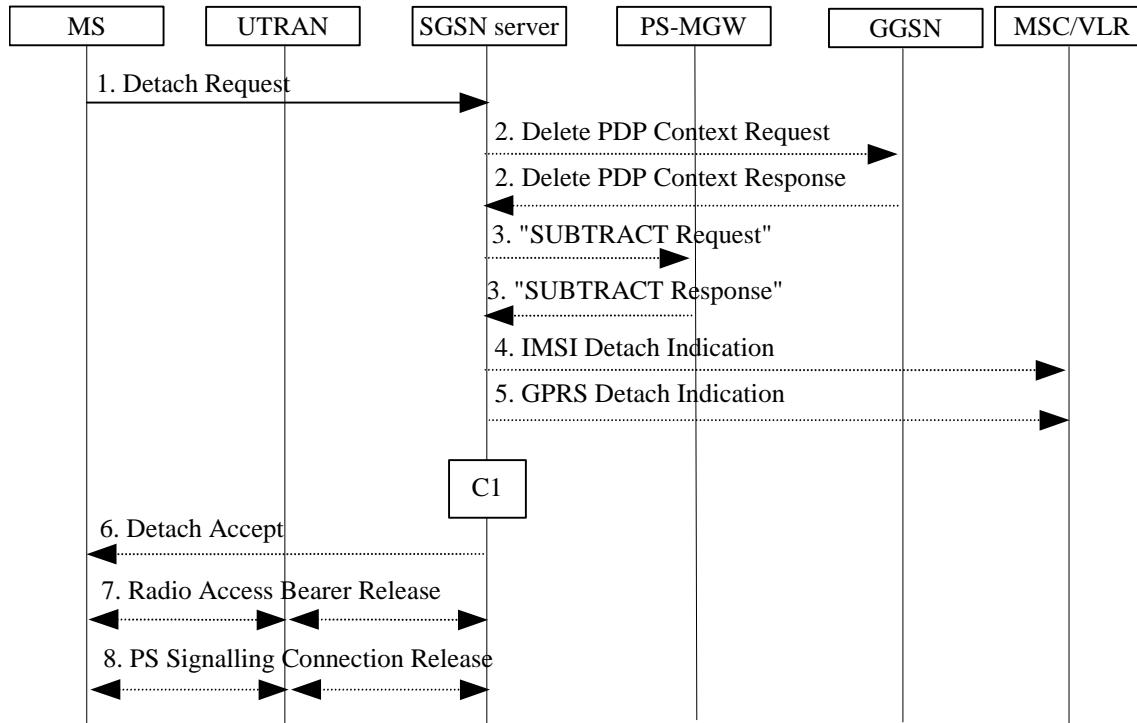
Figure 4: MS-Initiated Combined PS/CS Detach Procedure

1) The MS detaches by sending Detach Request to the SGSN server. Switch Off indicates whether the detach is due to a switch off situation or not.

2) If GPRS detach, the active PDP contexts in the GGSNs regarding this particular MS are deactivated by the SGSN server sending Delete PDP Context Request (TEID) to the GGSNs. The GGSNs acknowledge with Delete PDP Context Response (TEID).

3) If there are active PDP contexts, the SGSN server sends the "SUBTRACT Request" message to remove the corresponding GTP tunnel end points in the PS-MGW. When the PS-MGW has done this, it returns the "SUBTRACT Response" message to the SGSN server.

4) If IMSI detach, the SGSN server sends an IMSI Detach Indication (IMSI) message to the VLR.

5) If the MS wants to remain IMSI-attached and is doing a GPRS detach, the SGSN server sends a GPRS Detach Indication (IMSI) message to the VLR.

6) If Switch Off indicates that the detach is not due to a switch off situation, the SGSN server sends a Detach Accept to the MS.

7) If there were active PDP contexts, the corresponding RABs are released.

8) If the MS was GPRS detached, then the SGSN server releases the PS signalling connection.

6.3.1.2 Routing Area Update Procedure

The Iu connection is not active in the RA update procedure shown here. If the MS is in PMM-connected state, the SRNS relocation procedure would take place. After a SRNS relocation procedure is performed, a simplified RA update procedure would take place.
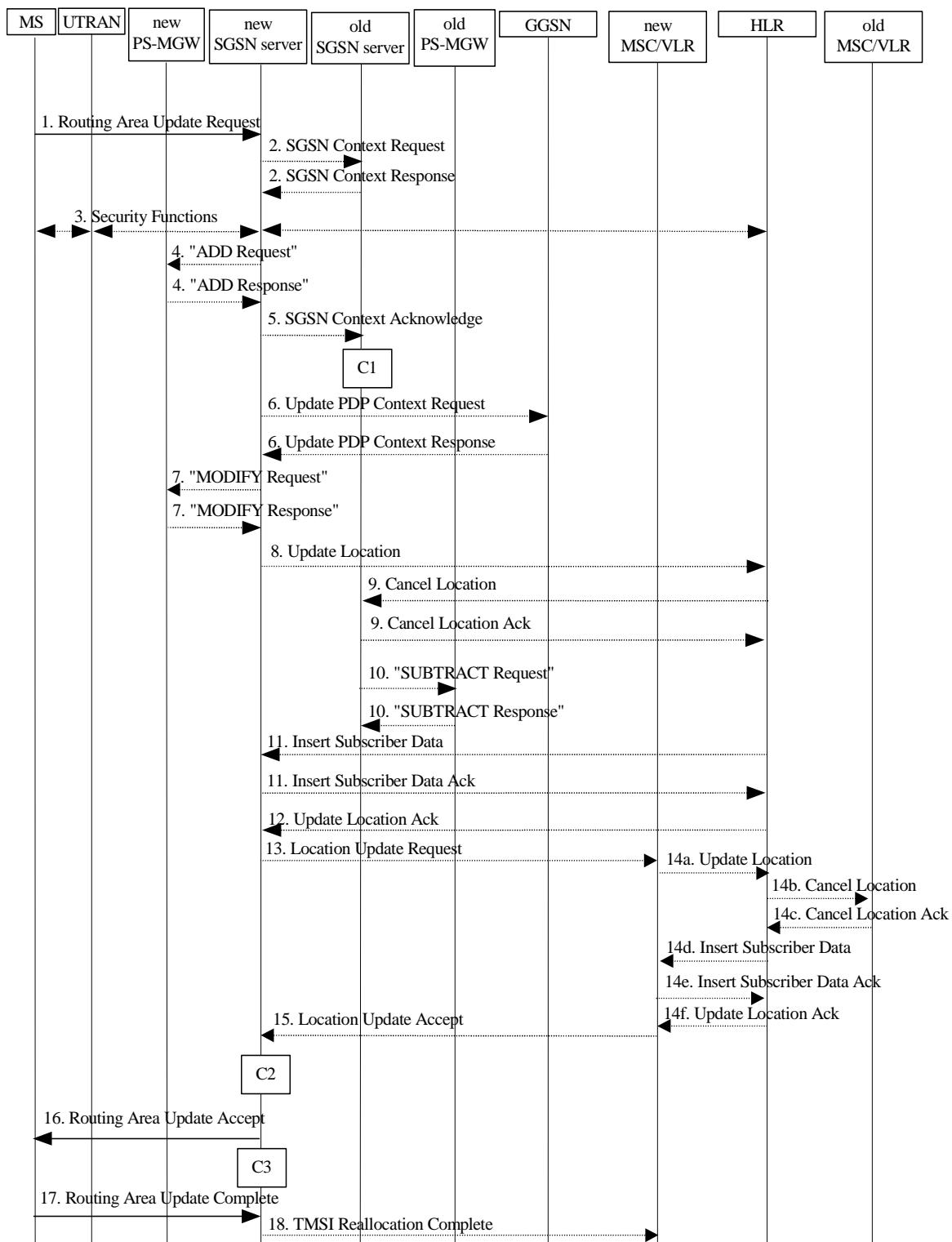
Figure 5: UMTS RA Update Procedure

1) The MS sends a Routeing Area Update Request message to the new SGSN server.

2) If the RA update is an Inter-SGSN Routeing area update and if the MS was in PMM-IDLE state, the new SGSN server sends SGSN Context Request message to the old SGSN server to get the MM and PDP contexts for the MS. The old SGSN server responds with a SGSN Context Response message. The old SGSN server starts a timer.

3) Security functions may be executed.

4) If the RA update is an Inter-SGSN RA Update and if the MS was in PMM-IDLE state, the new SGSN server selects a PS-MGW and sends the "ADD Request" message to the new PS-MGW to order setup of two GTP tunnel end points for every PDP context existing for the MS. The GTP tunnel end points are one towards UTRAN, and one towards the GGSN. The QoS attributes and the Allocation/Retention Priority parameter are included in the request.

The new PS-MGW returns the "ADD Response" message to the new SGSN server with the TEID(s) and the IP address(es) which UTRAN and GGSN shall use when sending GTP-U packets towards the new PS-MGW, for every PDP context existing for the MS.

[Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

5) Context Acknowledge message to the old SGSN server.

6) If the RA update is an Inter-SGSN RA Update and if the MS was in PMM-IDLE state, the new SGSN server sends an Update PDP Context Request to each of the GGSNs concerned. Included are the TEIDs and the IP addresses the GGSN(s) requires for communicating with the SGSN server and the PS-MGW. The GGSNs update their PDP context fields and return an Update PDP Context Response message, which includes the TEIDs and the IP addresses the SGSN server and the PS-MGW requires for communicating with the GGSN.

7) If the RA update is an Inter-SGSN RA Update and if the MS was in PMM-IDLE state, the new SGSN server sends the "MODIFY Request" message to the new PS-MGW. The TEIDs and the IP Addresses given are the one the new PS-MGW shall use when sending GTP-U packets towards the GGSN(s), and this is given for all the PDP contexts which are setup for the MS.

The PS-MGW returns the "MODIFY Response" message.

8) If the RA update is an Inter-SGSN RA Update, the new SGSN server informs the HLR of the change of SGSN server by sending Update Location to the HLR.

9) If the RA update is an Inter-SGSN RA Update, the HLR sends Cancel Location to the old SGSN server. If the timer described in step 2 is not running, then the old SGSN server removes the MM context. Otherwise, the contexts are removed only when the timer expires. The old SGSN server acknowledges with Cancel Location Ack.

10) If the RA update is an Inter-SGSN RA Update and if the MS was in PMM-IDLE state, the old SGSN server sends the "SUBTRACT Request" message to remove the GTP tunnel end points in the old PS-MGW.

The PS-MGW returns the "SUBTRACT Response" message.

The rest of the procedure is performed as described in TS 23.060.

6.3.1.3 Serving SRNS Relocation Procedure
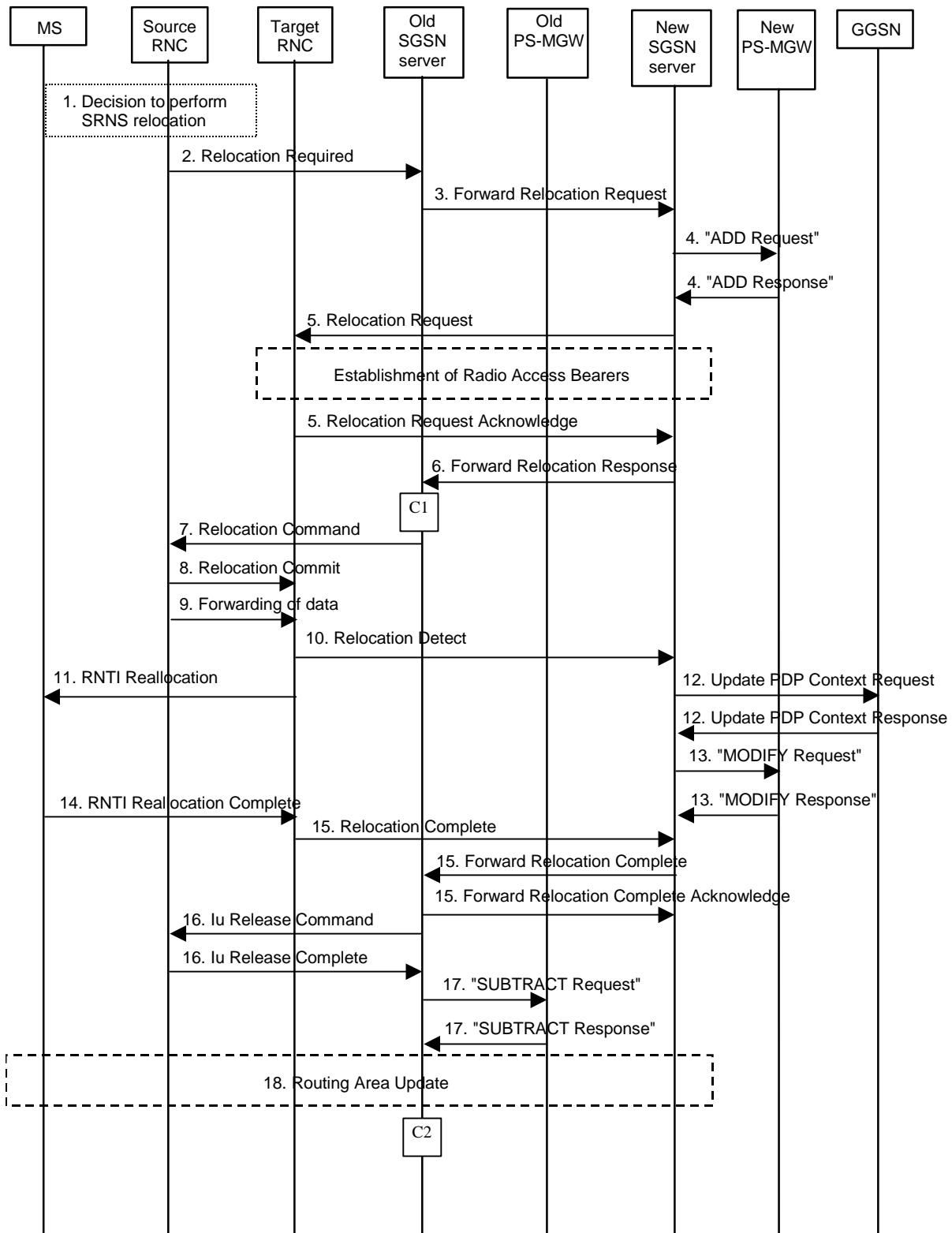
Figure 6: Serving SRNS Relocation procedure

1) The source SRNC decides to perform/initiate a SRNS relocation.

2) The source SRNC initiates the relocation preparation procedure by sending a Relocation Required message to the old SGSN server.

3) The old SGSN server determines from Target ID if the SRNS Relocation is intra SGSN SRNS relocation or inter SGSN SRNS relocation. In case of inter SGSN SRNS relocation the old SGSN server initiates the relocation resource allocation procedure by sending a Forward Relocation Request message to the new SGSN server. At the same time a timer is started on the MM and PDP contexts in the old SGSN server.

4) The new SGSN server selects a PS-MGW and sends the "ADD Request" message to the new PS-MGW to order setup of two GTP tunnel end points (one on the Iu interface and one on the Gn interface) for every PDP context that exists for the MS. The QoS attributes and the Allocation/Retention Priority parameter are included in the request.

   The new PS-MGW returns the "ADD Response" message to the new SGSN server with the TEIDs and the IP Addresses that the RNC and the GGSNs shall use when sending GTP-U packets towards the new PS-MGW.

   [Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

5) The new SGSN server sends a Relocation Request message to the target RNC. The new SGSN server passes the TEID(s) and the IP address(es) required at the target RNC for communicating with the new PS-MGW. Also, the SGSN server receives in the Relocation Request Acknowledge message the TEID(s) and the IP address(es) required at the PS-MGW to communicate with the target RNC.

6) When resources for the transmission of user data between the target RNC and the new PS-MGW has been allocated and the new SGSN server is ready for relocation of SRNS, the Forward Relocation Response message is sent from the new SGSN server to the old SGSN server. This message indicates that the target RNC is ready to receive from source SRNC the downstream packets not yet acknowledged by MS.
   The Forward Relocation Response message is applicable only in case of inter SGSN SRNS relocation.

7) The old SGSN server continues the relocation of SRNS by sending a Relocation Command message to the source SRNC.

8) Upon reception of the Relocation Command message from the PS domain, the source RNC shall start the data-forwarding timer. When the relocation preparation procedure is terminated successfully and when the source SRNC is ready, the source SRNC shall trigger the execution of relocation of SRNS by sending a Relocation Commit message (SRNS Contexts) to the target RNC. The purpose of this procedure is to transfer SRNS contexts from the source RNC to the target RNC.

9) After having sent the Relocation Commit message, the source SRNC begins the forwarding of data for the RABs to be subject for data forwarding. The data forwarding at SRNS relocation shall be carried out through the Iu interface, meaning that the data exchanged between the source SRNC and the target RNC are duplicated in the source SRNC and routed at IP layer towards the target RNC.

10) The target RNC shall send a Relocation Detect message to the new SGSN server when the relocation execution trigger is received. When the Relocation Detect message is sent, the target RNC shall start SRNC operation.

11) After having sent the Relocation Detect message, target SRNC responds to the MS by sending a RNTI Reallocation message.

12) Upon reception of Relocation Detect message, CN may switch the user plane from the source RNC to the target SRNC. If the SRNS Relocation is an inter SGSN SRNS relocation, the new SGSN server sends Update PDP Context Request messages to the GGSNs concerned, with the TEIDs and the IP addresses required at the GGSNs for communicating with the SGSN server and the PS-MGW. The GGSNs update their PDP context fields and return an Update PDP Context Response with the TEIDs and the IP addresses required at the SGSN server and the PS-MGW for communicating with the GGSN.

14) The new SGSN server sends the "MODIFY Request" message to the new PS-MGW with the TEIDs and the IP Addresses that the new PS-MGW requires for communicating with the target RNC and the GGSNs. This is given for all the PDP contexts that are setup for the MS.

   The PS-MGW returns the "MODIFY Response" message.

15) When the MS has reconfigured itself, it sends the RNTI Reallocation Complete message to the target SRNC. From now on the exchange of packets with the MS can start.

16) When the target SRNC receives the RNTI Reallocation Complete message, the target SRNC shall initiate the Relocation Complete procedure by sending the Relocation Complete message to the new SGSN server.

If the SRNS Relocation is an inter SGSN SRNS relocation, the new SGSN server signals to the old SGSN server the completion of the SRNS relocation procedure by sending a Forward Relocation Complete message.

17) The old SGSN server sends an Iu Release Command message to the source RNC. When the RNC data-forwarding timer has expired the source RNC responds with an Iu Release Complete.

18) Upon receiving the Forward Relocation Complete message, the old SGSN server sends the "SUBTRACT Request" message to remove the GTP tunnel end points in the old PS-MGW.

The PS-MGW returns the "SUBTRACT Response" message.

19) After the MS has finished RNTI reallocation procedure and if the new Routing Area Identification is different from the old one, the MS initiates the Routing Area Update procedure.

C1) CAMEL-GPRS-SGSN-Context-Acknowledge.

C2) CAMEL-GPRS-Routing-Area-Update.

6.3.1.4 UMTS to GSM Intra SGSN Change
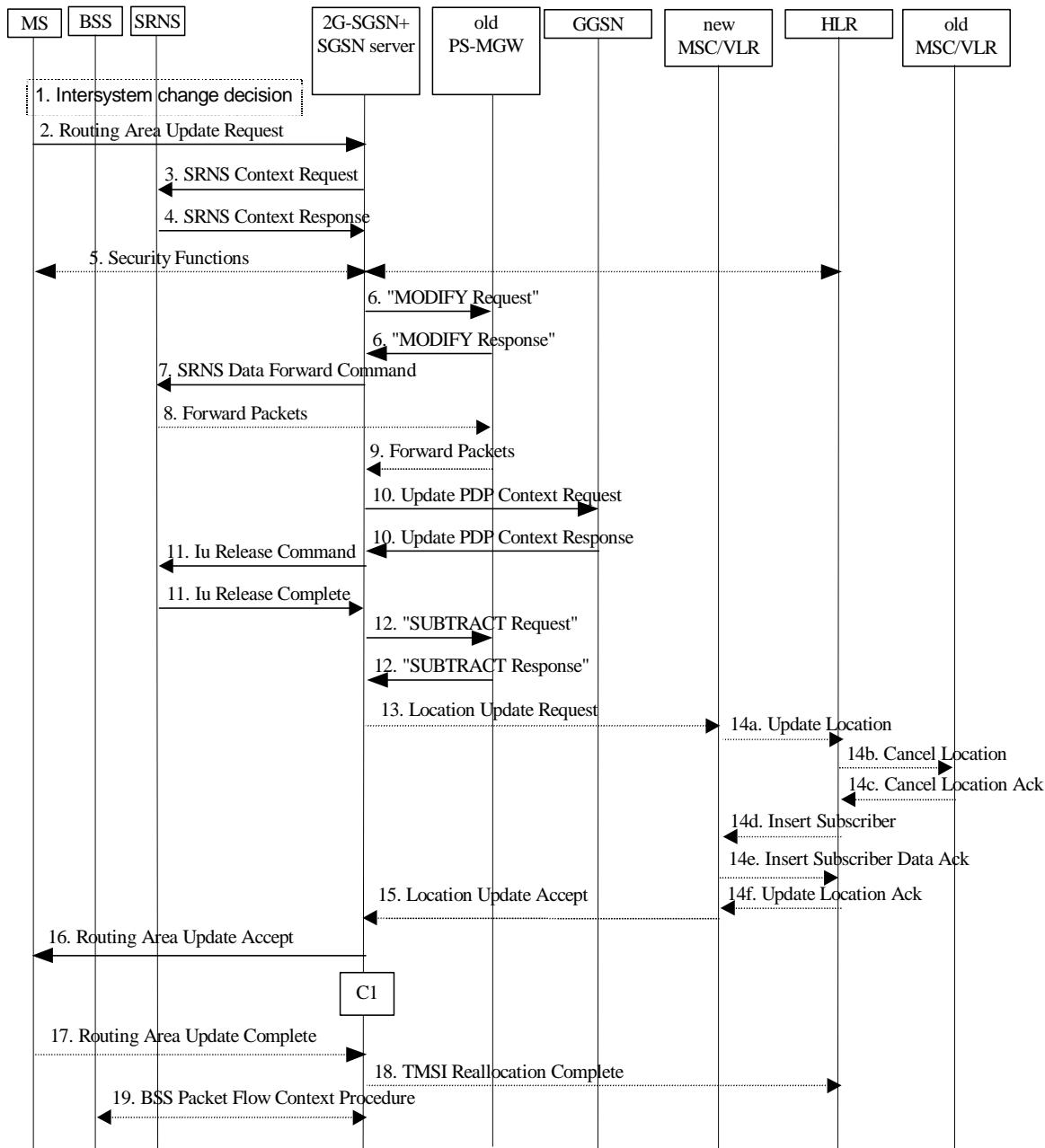
Figure 7: UMTS to GSM Intra SGSN Change

1) The MS or BSS or UTRAN decides to perform an intersystem change, which makes the MS switch to a new cell that supports GSM radio technology, and stops transmission to the network.

2) The MS sends a Routeing Area Update Request message to the 2G-SGSN+SGSN server.

3) The 2G-SGSN+SGSN server sends an SRNS Context Request message to the SRNS.

4) Upon reception of this message the SRNS buffers and stops sending downlink PDUs to the MS and returns an SRNS Context Response message.

5) Security functions may be executed.

6) The 2G-SGSN+SGSN server sends the "MODIFY Request" message to the old PS-MGW to modify the TEID(s) and the IP address(es) earlier pointing to the GGSN(s) into now pointing to the new 2G-SGSN+SGSN server for every PDP context existing for the MS. For each active PDP context using acknowledged mode, an

indicator is included to tell the PS-MGW that the eight most significant bits of the PDCP sequence numbers accompanying the received G-PDUs must be stripped off. This enables the old PS-MGW to forward packets to the 2G-SGSN+SGSN server in the appropriate format.

The old PS-MGW returns the "MODIFY Response" message.

7) If the MS is PMM-CONNECTED the 2G-SGSN+SGSN server sends an SRNS Data Forward Command message to the SRNS with the TEID(s) and IP address(es) required at the SRNS for packet forwarding to the old PS-MGW. Upon reception of SRNS Data Forward Command message from the 2G-SGSN+SGSN server, the SRNS shall start the data-forwarding timer.

8) The SRNS shall start tunnelling the partly transmitted and the transmitted but not acknowledged PDCP-PDUs and start duplicating and tunnelling the buffered GTP PDUs to the old PS-MGW.

9) The old PS-MGW tunnels the G-PDUs to the 2G-SGSN+SGSN server. For each active PDP context using acknowledged mode, the PS-MGW must strip off the eight most significant bits of the PDCP sequence numbers.

10) The 2G-SGSN+SGSN server sends an Update PDP Context Request message to each GGSN concerned with the TEIDs and the IP addresses required at the GGSNs for communication towards the 2G-SGSN+SGSN server. Each GGSN updates its PDP context fields and returns an Update PDP Context Response message.

11) When the MS is PMM-CONNECTED the 2G-SGSN+SGSN server sends an Iu Release Command message to the SRNS. When the RNC data-forwarding timer has expired, the SRNS responds with an Iu Release Complete message.

12) The 2G-SGSN+SGSN server sends the "SUBTRACT Request" message to remove the GTP tunnel end points in the old PS-MGW.

The PS-MGW returns the "SUBTRACT Response" message.

The rest of the procedure is performed as described in TS 23.060.

[Note: the PS-MGW may be implemented with the SGSN server in a combined node, and in this case the signalling towards the PS-MGW and the GGSN may be omitted.]

6.3.1.5 GSM to UMTS Intra SGSN Change
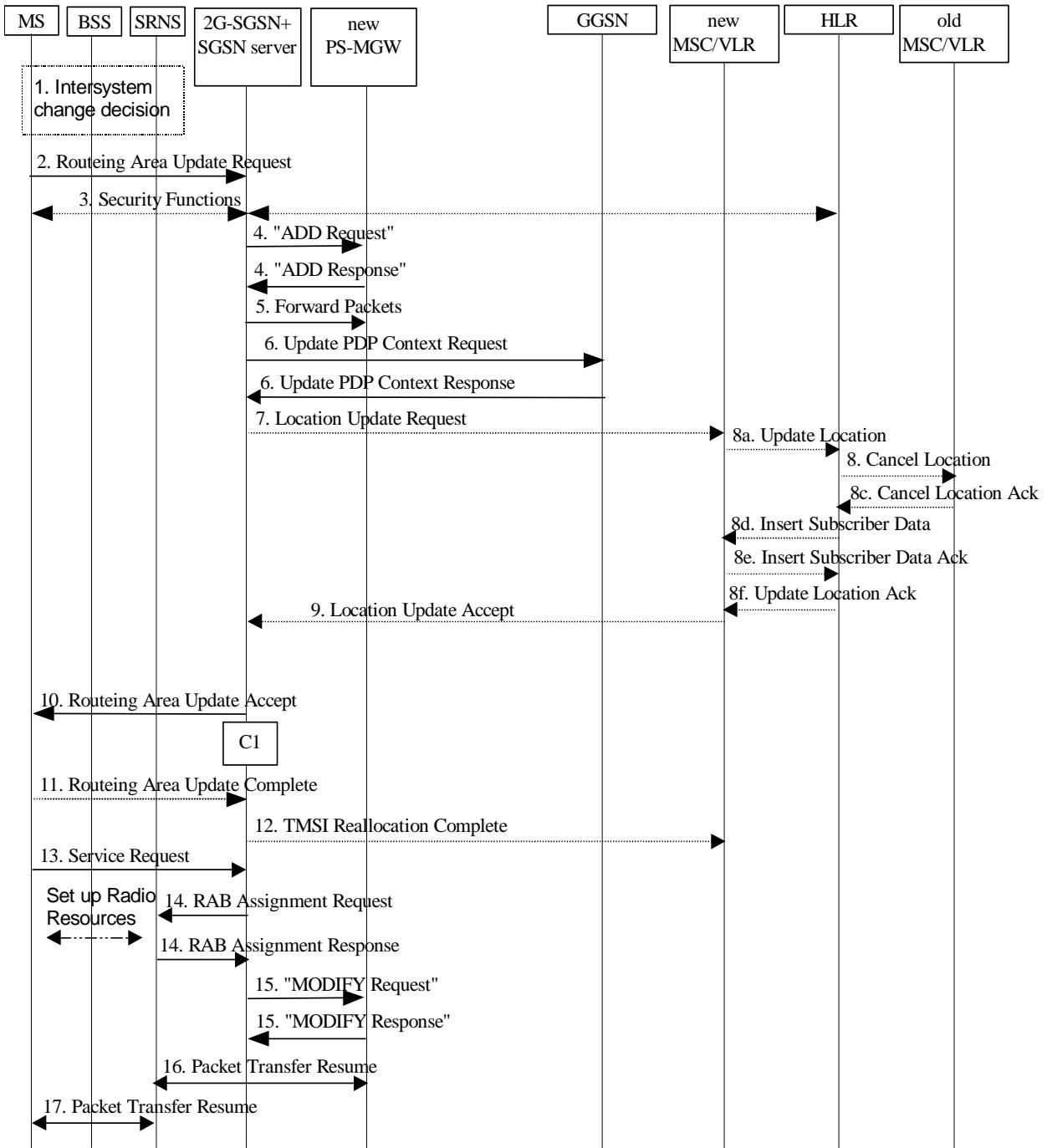
Figure 8: GSM to UMTS Intra SGSN Change

1) The MS or BSS or UTRAN decides to perform an intersystem change, which makes the MS switch to a new cell that supports UMTS radio technology, and stops transmission to the network.

2) The MS sends a Routeing Area Update Request message to the 2G-SGSN+SGSNserver. The 2G-SGSN+SGSN server starts a timer and stops the transmission of N-PDUs to the MS.

3) Security functions may be executed.

4) The 2G-SGSN+SGSN server selects a PS-MGW and sends the "ADD Request" message to the new PS-MGW to order setup of two GTP tunnel end points for every PDP context existing for the MS. The GTP tunnel end points

are one towards UTRAN, and a common one towards the GGSN and towards the 2G-SGSN+SGSN server. The QoS attributes and the Allocation/Retention Priority parameter are included in the request.

The new PS-MGW returns the "ADD Response" message to the 2G-SGSN +SGSN server with the TEID(s) and the IP address(es) which UTRAN, the 2G-SGSN+SGSN server and the GGSN shall use when sending G-PDUs towards the new PS-MGW, for every PDP context existing for the MS.

[Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

5) The 2G-SGSN+SGSN server duplicates the buffered G-PDUs and starts tunnelling them to the new PS-MGW. No G-PDUs shall be forwarded to the new PS-MGW after expiry of the timer described in step 2.

6) The 2G-SGSN+SGSN server sends an Update PDP Context Request message to each GGSN concerned with the TEIDs and the IP addresses required at the GGSNs for communication towards the 2G-SGSN+SGSN server and the PS-MGW. Each GGSN updates its PDP context fields and return an Update PDP Context Response message with the TEIDs and the IP addresses required at the 2G-SGSN+SGSN server and the PS-MGW for communication towards the GGSN.

7) to 12)   As described in TS 23.060.

13) The MS sends a Service Request message to the 2G-SGSN+SGSN server with the Service Type indicating Data or Signalling.

14) The 2G-SGSN+SGSN server requests the SRNS to establish a radio access bearer by sending a RAB Assignment Request message to the SRNS. Included are the TEID(s) and the IP address(es) which the SRNS requires to communicate with the new PS-MGW. The SRNS sends a Radio Bearer Setup Request message to the MS. The MS responds with a Radio Bearer Setup Complete message.The SRNS responds with a RAB Assignment Response message with the TEID(s) and the IP address(es) required at the PS-MGW for communicating with the SRNS.

15) The 2G-SGSN+SGSN server sends the "MODIFY Request" message to the new PS-MGW. The TEIDs and the IP Addresses given are the one the new PS-MGW must use when sending G-PDUs towards UTRAN and the GGSN(s), and this is given for all the PDP contexts which are setup for the MS.

The PS-MGW returns the "MODIFY Response" message.

16) Traffic flow is resumed between the PS-MGW and the SRNS. The SRNS shall discard all G-PDUs with PDCP-PDU sequence numbers older than the downlink PDCP-PDU sequence number received from the MS. Other G-PDUs shall be transmitted to the MS. The MS shall discard all PDCP-PDUs with sequence numbers older than the GTP-SNU received from the SRNS. If this is not the case, the PDCP-PDUs shall be transmitted to the SRNS.

17) The traffic flow is resumed between the SRNS and the MS.

[Note, the PS-MGW may be implemented with the SGSN server in a combined node, and in this case the signalling towards the PS-MGW and the GGSN may be omitted.]

## 6.3.1.6 UMTS to GSM Inter SGSN Change
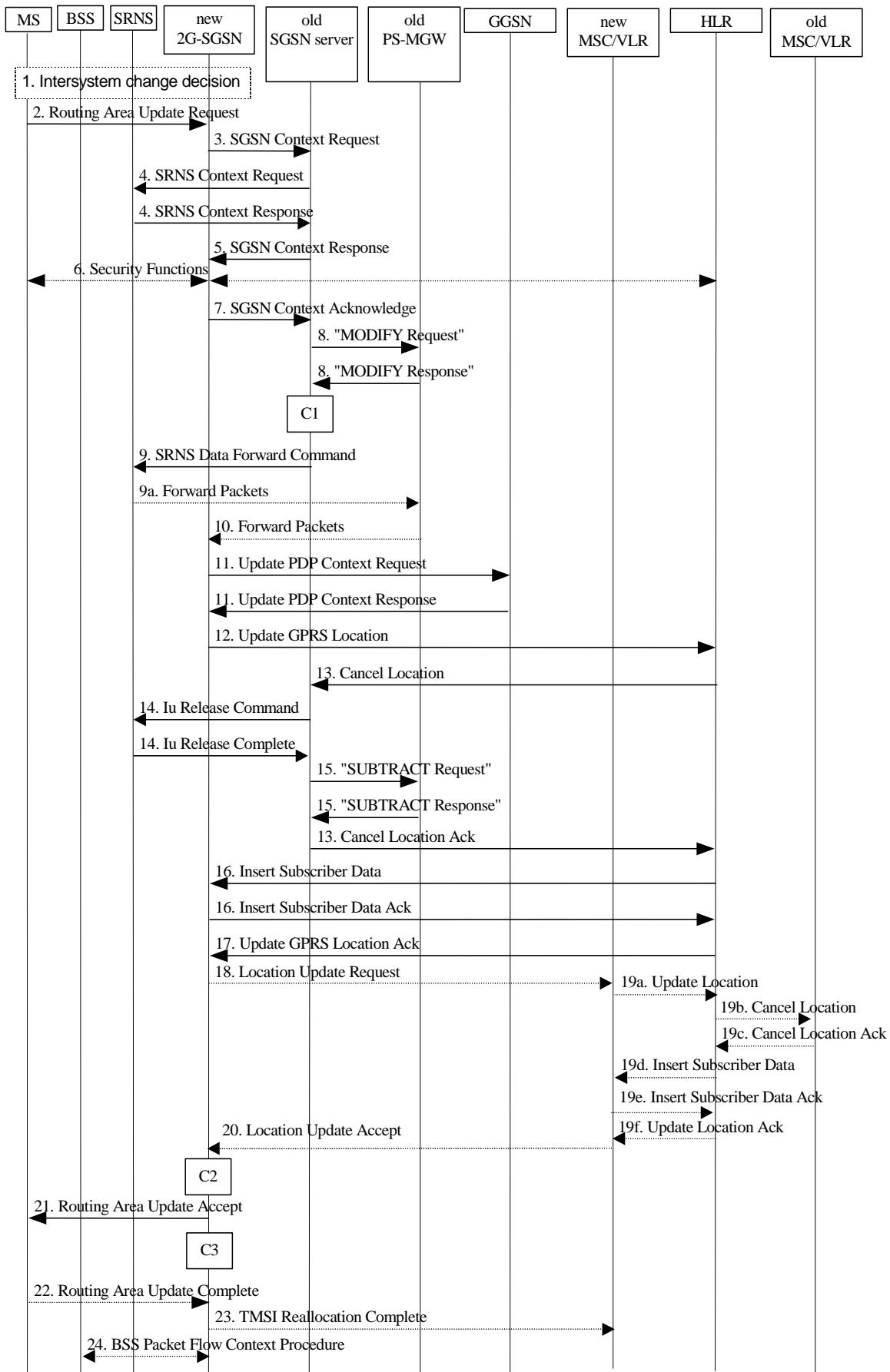
Figure 9: UMTS to GSM Inter SGSN Change

1) The MS or BSS or UTRAN decides to perform an intersystem change, which makes the MS switch to a new cell that supports GSM radio technology, and stops transmission to the network.

2) The MS sends a Routeing Area Update Request message to the new 2G-SGSN.

3) The new 2G-SGSN sends an SGSN Context Request message to the old SGSN server to get the MM and PDP contexts for the MS. The old SGSN server starts a timer.

4) If the MS is PMM-CONNECTED, the old SGSN server sends an SRNS Context Request message to the SRNS. Upon reception of this message the SRNS buffers and stops sending downlink PDUs to the MS and returns an SRNS Context Response message.

5) The old SGSN server responds with an SGSN Context Response message.

6) Security functions may be executed.

7) The new 2G-SGSN sends an SGSN Context Acknowledge message to the old SGSN server with the TEID(s) and the IP address required at the old PS-MGW for packet forwarding. This informs the old SGSN server that the new 2G-SGSN is ready to receive data packets belonging to the activated PDP contexts.

8) The old SGSN server sends the "MODIFY Request" message to the old PS-MGW to modify the TEID(s) and the IP address(es) earlier pointing to the GGSN(s) into now pointing to the new 2G-SGSN for every PDP context existing for the MS. For each active PDP context using acknowledged mode, an indicator is included to tell the PS-MGW that the eight most significant bits of the PDCP sequence numbers accompanying the received G-PDUs must be stripped off, thus converting them to SNDCP sequence numbers. This enables the old PS-MGW to forward packets to the new 2G-SGSN in the appropriate format.

   The old PS-MGW returns the "MODIFY Response" message.

9) If the MS is PMM-CONNECTED the old SGSN server sends an SRNS Data Forward Command message to the SRNS with the TEID(s) and IP address(es) required at the SRNS for packet forwarding to the old PS-MGW. The SRNS shall start tunnelling the partly transmitted and the transmitted but not acknowledged PDCP-PDUs and start duplicating and tunnelling the buffered GTP PDUs to the old PS-MGW. Upon reception of SRNS Data Forward Command message from the SGSN server, the SRNS shall start the data-forwarding timer.

10) The old PS-MGW tunnels the G-PDUs to the new 2G-SGSN. For each active PDP context using acknowledged mode, the PS-MGW must strip off the eight most significant bits of the PDCP sequence numbers accompanying the received G-PDUs.

11) The new 2G-SGSN sends an Update PDP Context Request message to each GGSN concerned. Each GGSN updates its PDP context fields and returns an Update PDP Context Response message.

12) The new 2G-SGSN informs the HLR of the change of SGSN by sending an Update GPRS Location message to the HLR.

13) The HLR sends a Cancel Location message to the old SGSN server. The old SGSN server acknowledges with a Cancel Location Ack message. The old SGSN server removes the MM and PDP contexts if the timer described in step 3 is not running. If the timer is running, then the MM and PDP context shall be removed when the timer expires.

14) When the MS is PMM-CONNECTED the old SGSN server sends an Iu Release Command message to the SRNS. When the RNC data-forwarding timer has expired the SRNS responds with an Iu Release Complete message.

15) The old SGSN server sends the "SUBTRACT Request" message to remove the GTP tunnel end points in the old PS-MGW.

   The PS-MGW returns the "SUBTRACT Response" message.

The rest of the procedure is performed as described in TS 23.060.

6.3.1.7 GSM to UMTS Inter SGSN Change
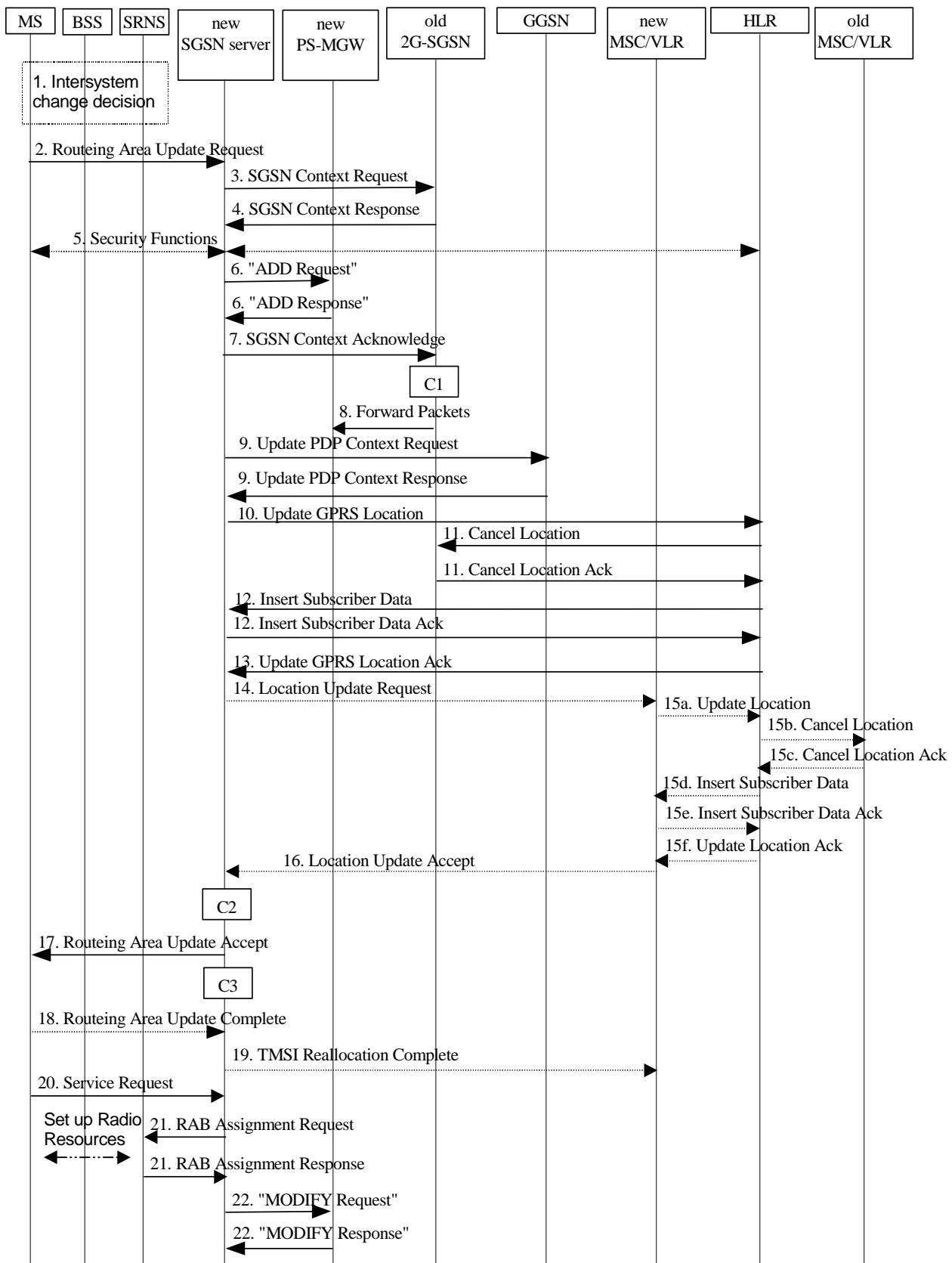
Figure 10: GSM to UMTS Inter SGSN Change

1) The MS or BSS or UTRAN decides to perform an intersystem change, which makes the MS switch to a new cell that supports UMTS radio technology, and stops transmission to the network.

2) The MS sends a Routeing Area Update Request message to the new SGSN server.

3) The new SGSN server sends an SGSN Context Request message to the 2G-SGSN to get the MM and PDP contexts for the MS. The old 2G-SGSN starts a timer and stops the transmission of N-PDUs to the MS.

4) The old 2G-SGSN responds with an SGSN Context Response message.

5) Security functions may be executed.

6) The new SGSN server selects a PS-MGW and sends the "ADD Request" message to the new PS-MGW to order setup of two GTP tunnel end points for every PDP context existing for the MS. The GTP tunnel end points are one towards UTRAN, and a common one towards the GGSN and towards the old 2G-SGSN. The QoS attributes and the Allocation/Retention Priority parameter are included in the request.

   The new PS-MGW returns the "ADD Response" message to the new SGSN server with the TEID(s) and the IP address(es) which UTRAN, old 2G-SGSN and GGSN shall use when sending G-PDUs towards the new PS-MGW, for every PDP context existing for the MS.

   [Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

7) The new SGSN server sends an SGSN Context Acknowledge message to the old 2G-SGSN. This informs the old 2G-SGSN that the new PS-MGW is ready to receive data packets belonging to the activated PDP contexts. Included are the TEID(s) and the IP address that the old 2G-SGSN requires to forward packets to the new PS-MGW.

8) The old 2G-SGSN duplicates the buffered G-PDUs and starts tunnelling them to the new PS-MGW. No G-PDUs shall be forwarded to the new PS-MGW after expiry of the timer described in step 3.

9) The new SGSN server sends an Update PDP Context Request message to each GGSN concerned with the TEIDs and the IP addresses required at the GGSNs for communication towards the new SGSN server and the PS-MGW. Each GGSN updates its PDP context fields and return an Update PDP Context Response message with the TEIDs and the IP addresses required at the new SGSN server and the PS-MGW for communication towards the GGSN.

10) to 19) As described in TS 23.060.

20) If the MS was in GPRS MM state READY, it sends a Service Request message to the new SGSN server.

21) If the MS has sent the Service Request the new SGSN server requests the SRNS to establish a radio access bearer by sending a RAB Assignment Request message to the SRNS. Included are the TEID(s) and the IP address(es) which the SRNS requires to communicate with the new PS-MGW. The SRNS responds with a RAB Assignment Response message with the TEID(s) and IP address(es) required at the PS-MGW for communicating with the SRNS.

22) The new SGSN server sends the "MODIFY Request" message to the new PS-MGW. The TEIDs and the IP Addresses given are the one the new PS-MGW shall use when sending G-PDUs towards UTRAN and GGSN(s), and this is given for all the PDP contexts which are setup for the MS.

   The PS-MGW returns the "MODIFY Response" message.

6.3.2 Session Management (H.248 option)

6.3.2.1 PDP Context Activation Procedure
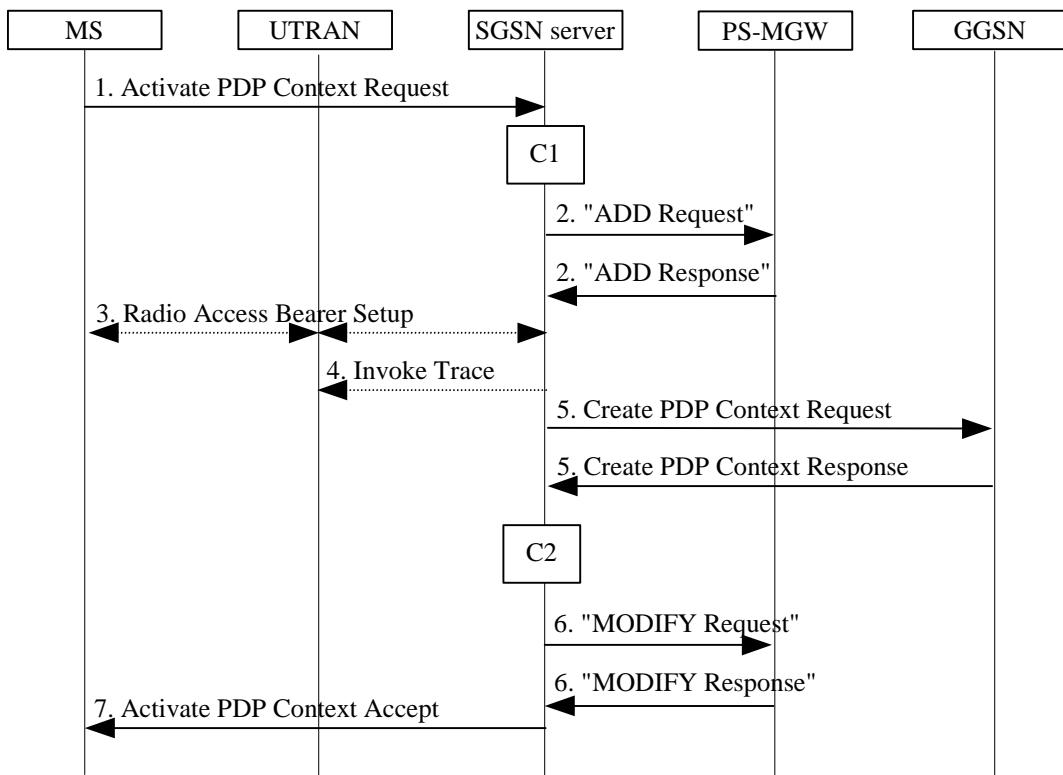
Figure 11: PDP Context Activation Procedure for UMTS

1) The MS sends an Activate PDP Context Request (NSAPI, TI, PDP Type, PDP Address, Access Point Name, QoS Requested, PDP Configuration Options) message to the SGSN server.

2) The SGSN server validates the Activate PDP context request message. The SGSN server may restrict the requested QoS attributes, given the subscribed QoS profile. If the SGSN server determines that the PDP context activation can be completed, the SGSN server selects a PS-MGW and sends the "ADD Request" message to the PS-MGW to order it to setup two GTP tunnel end points (one on the Iu interface and one on the Gn interface). The (possibly restricted) QoS attributes and the Allocation/Retention priority parameter are included in the "ADD Request" message so that the MGW can handle the different sessions accordingly.

   The PS-MGW returns the "ADD Response" message with the TEIDs and the IP addresses for the GTP tunnel end points to be used at the RNC and the GGSN when these send GTP-U packets towards the PS-MGW.

   [Note: With H.248 the PS-MGW cannot select a different QoS than proposed by the SGSN server. H.248 allows the SGSN server to send a prioritised list of QoS values, either discrete values or between a minimum and a maximum. The PS-MGW will then return the chosen value in the response to the SGSN server. If the PS-MGW cannot support any of the indicated values, a negative response is returned to the SGSN server.

   Note that this QoS handling is similar to the QoS handling in the RANAP protocol. Currently, the RNC can only accept or reject the QoS value indicated by the SGSN server. There is an ongoing discussion to extend this functionality. E.g. that the SGSN server can relay to the RNC several proposed values indicated by the MS. The RNC could then choose the value it can support. This handling is currently possible to support by H.248. It is proposed to choose the same QoS handling mechanism over the Mp interface as will eventually be standardised in RANAP].

3) In UMTS, RAB setup is done by the RAB Assignment procedure. The TEID and the IP address which UTRAN requires for communication towards the PS-MGW, and vice versa, are handled in this procedure.

4) If trace is activated, then the SGSN server shall send an Invoke Trace message to the UTRAN.

5) The SGSN server sends a Create PDP Context Request message to the affected GGSN with the TEIDs and the IP addresses that the GGSN requires for communication towards the SGSN server and the PS-MGW.

The GGSN then returns a Create PDP Context Response message to the SGSN server with the TEIDs and the IP addresses that the SGSN server and the PS-MGW require for communication towards the GGSN. The GGSN may further restrict the QoS negotiated returned in the response message.

6) The SGSN server sends the "MODIFY Request" message to the PS-MGW with the TEIDs and the IP addresses that the PS-MGW requires for communication towards the RNC and the GGSN. Also the GTP version negotiated in the control plane layer is sent in this message.

If a new negotiated value of the QoS attributes is received from the GGSN, this value is transferred to the PS-MGW in the "MODIFY Request" message.

The PS-MGW returns the "MODIFY Response" message.

7) The SGSN server returns an Activate PDP Context Accept (PDP Address, Packet Flow Id) message to the MS. The SGSN server is now able to route PDP PDUs between the GGSN and the MS, and charging can be started.

C1) CAMEL-GPRS-Activate-PDP-Context.

C2) CAMEL-GPRS-SGSN-Create-PDP-Context.

6.3.2.2 Secondary PDP Context Activation Procedure

The Secondary PDP Context Activation procedure may be used to activate a PDP context while reusing the PDP address and other PDP context information from an already active PDP context.
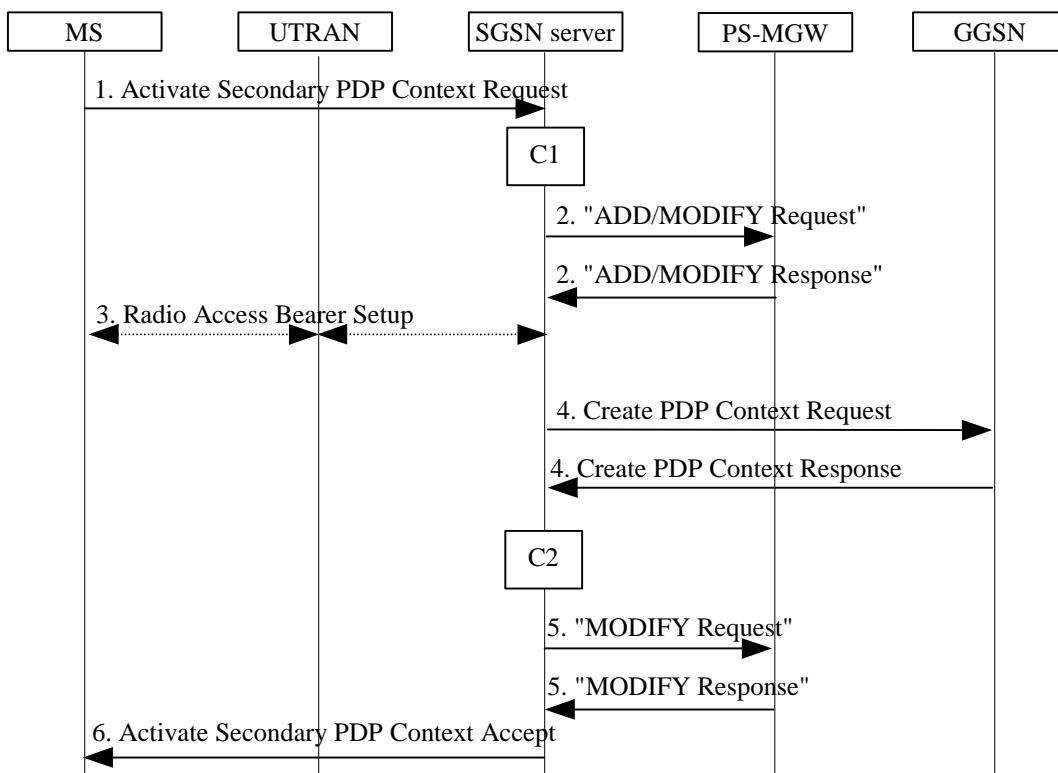
Figure 12: Secondary PDP Context Activation Procedure for UMTS

1) The MS sends an Activate Secondary PDP Context Request (Linked TI, NSAPI, TI, QoS Requested, TFT) message to the SGSN server. Linked TI indicates the TI value assigned to any one of the already activated PDP contexts for this PDP address and APN.

2) The SGSN server validates the Activate Secondary PDP context request message. The SGSN server may restrict the requested QoS attributes, given the subscribed QoS profile. If the SGSN server determines that the PDP

context activation can be completed, the SGSN server selects a PS-MGW and sends the "ADD/MODIFY Request" message to the PS-MGW to order it to setup two GTP tunnel end points (one on the Iu interface and one on the Gn interface). The (possibly restricted) QoS attributes and the Allocation/Retention priority parameter are included in the "ADD/MODIFY Request" message so that the MGW can handle the different sessions accordingly.

The PS-MGW returns the "ADD/MODIFY Response" message with the TEIDs and the IP addresses for the GTP tunnel end points to be used at the RNC and the GGSN when these send GTP-U packets towards the PS-MGW.

If each of the GTP tunnel end points for every PDP context are set up in a separate H.248 Termination, the "ADD" command is used in this step. If the GTP tunnel end points on the same interface (Iu or Gn) are set up in the same H.248 Termination for all the PDP contexts sharing a given PDP address and APN, then the "MODIFY" command is used in this step.

[Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

3) In UMTS, RAB setup is done by the RAB Assignment procedure. The TEID and the IP address which UTRAN requires for communication towards the PS-MGW, and vice versa, are handled in this procedure.

4) The SGSN server sends a Create PDP Context Request message to the affected GGSN with the TEIDs and the IP addresses that the GGSN requires for communication towards the SGSN server and the PS-MGW.

The GGSN then returns a Create PDP Context Response message to the SGSN server with the TEIDs and the IP addresses that the SGSN server and the PS-MGW require for communication towards the GGSN. The GGSN may further restrict the QoS negotiated returned in the response message.

5) The SGSN server sends the "MODIFY Request" message to the PS-MGW with the TEIDs and the IP addresses that the PS-MGW requires for communication towards the RNC and the GGSN. Also the GTP version negotiated in the control plane layer is sent in this message.

If a new negotiated value of the QoS attributes is received from the GGSN, this value is transferred to the PS-MGW in the "MODIFY Request" message.

The PS-MGW returns the "MODIFY Response" message.

6) The SGSN server returns an Activate Secondary PDP Context Accept message to the MS. The SGSN server is now able to route PDP PDUs between the GGSN and the MS.

C1)   CAMEL-GPRS-Activate-PDP-Context.

C2)   CAMEL-GPRS-SGSN-Create-PDP-Context.

6.3.2.3   Network-Requested PDP Context Activation Procedure

The Network-Requested PDP Context Activation procedure allows the GGSN to initiate the activation of a PDP context. This procedure is a request in the control plane towards the MS to initiate a PDP Context Activation procedure. The PDP Context Activation procedure itself is performed as shown above in Section 0. Therefore the Network-Requested PDP Context Activation procedure does not add any new sequences for the split of the SGSN (into an SGSN server and a PS-MGW).

Note that push services will require some attention. Push services are not yet standardised, but there might be a need for the SGSN server to ask the PS-MGW for its capability of handling the push service before the SGSN server requests the MS to initiate the activation of a PDP context.

6.3.2.4   PDP Context Modification Procedures

The following parameters can be modified in a PDP context modification procedure:

- QoS Negotiated;

- Radio Priority;

- Packet Flow Id;

- PDP Address (in case of the GGSN-initiated modification procedure); and

- TFT (in case of MS-initiated modification procedure).

Of these parameters, only the modification of the QoS Negotiated affects the PS-MGW.

The modification procedure can be initiated by:

- the SGSN;

- the GGSN;

- the MS; or

- the RNC

Since the principle of modifying the QoS attributes in the PS-MGW is the same for all these cases, only one of them is shown – the MS initiated PDP context modification. As a downgrade of the QoS attributes is a simplified case of the upgrade modification procedure, the latter case is described.
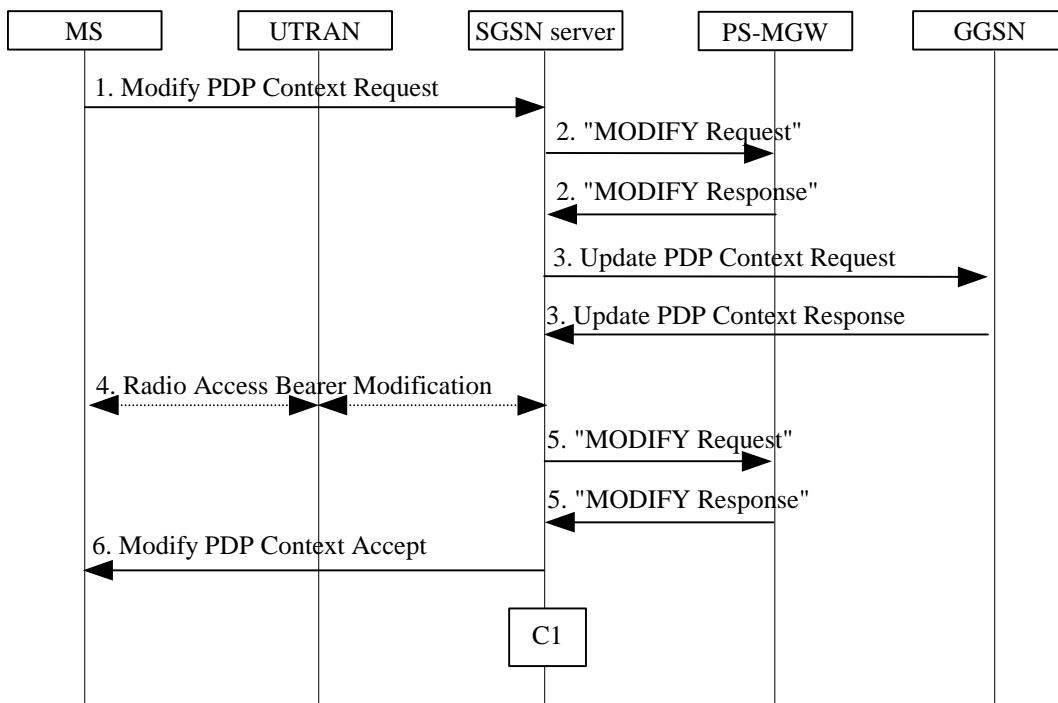
Figure 13: MS-Initiated PDP Context Modification Procedure for UMTS

1) The MS sends a Modify PDP Context Request (TI, QoS Requested, TFT) message to the SGSN server.

2) The SGSN server may restrict the requested QoS attributes, given the subscribed QoS profile. The SGSN server sends the "MODIFY Request" message to the PS-MGW. This message includes the (possibly restricted) QoS attributes.

   The PS-MGW returns the "MODIFY Response" message.

   [Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]

3) The SGSN server sends an Update PDP Context Request (TEID, NSAPI, QoS Negotiated, TFT) message to the GGSN. The GGSN may further restrict QoS Negotiated given its capabilities and the current load, and returns an Update PDP Context Response (TEID, QoS Negotiated) message.

   If QoS Negotiated and/or TFT received from the SGSN is incompatible with the PDP context being modified (e.g., TFT contains inconsistent packet filters), then the GGSN rejects the Update PDP Context Request.

4) In UMTS, radio access bearer modification may be performed by the RAB Assignment procedure.

5) In case the QoS now is different than the value previously indicated to the PS-MGW, the new value is sent from the SGSN server to the PS-MGW in the "MODIFY Request" message.

The PS-MGW returns the "MODIFY Response" message.

6) The SGSN server selects Radio Priority and Packet Flow Id based on QoS Negotiated, and returns a Modify PDP Context Accept (TI, QoS Negotiated, Radio Priority, Packet Flow Id) message to the MS.

NOTE: If the SGSN server or the PS-MGW do not accept QoS Requested, then steps 2 and 3 of this procedure are skipped, and the existing QoS Negotiated is returned to the MS in step 4.

C1) CAMEL-GPRS-Modify-PDP-Context.

6.3.2.5 PDP Context Deactivation Procedure

PDP context deactivation can be initiated by the MS, by the SGSN and by the GGSN. The latter two sequences are omitted in this description as they are similar to the first sequence, and they do not add any complexity to the deactivation sequences.
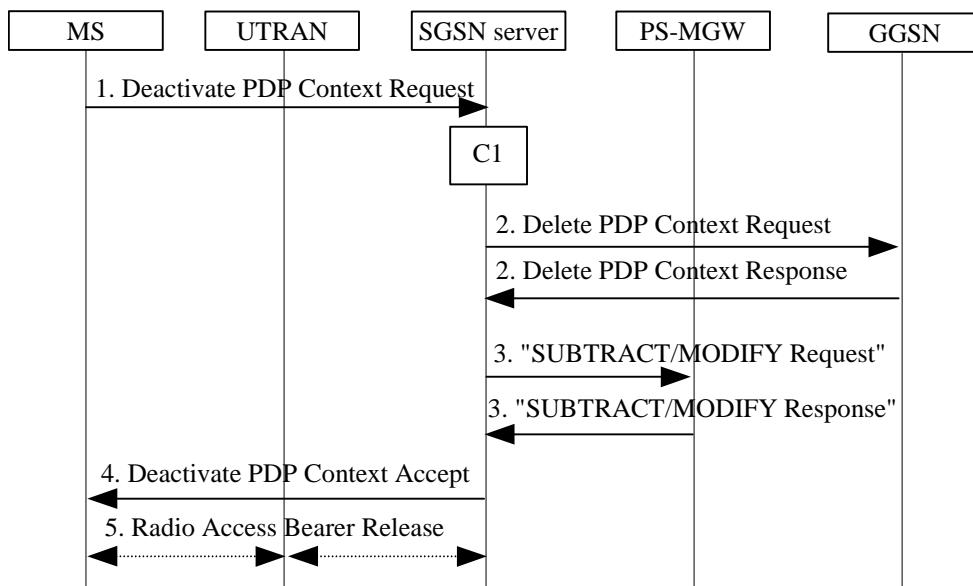
Figure 14: PDP Context Deactivation Initiated by MS Procedure for UMTS

1) The MS sends a Deactivate PDP Context Request (TI, Teardown Ind) message to the SGSN server.

2) The SGSN server sends a Delete PDP Context Request (TED, NSAPI, Teardown Ind) message to the GGSN. If Teardown Ind was included by the MS in the Deactivate PDP Context Request message, then the SGSN server deactivates all PDP contexts associated with this PDP address by including Teardown Ind in the Delete PDP Context Request message. The GGSN removes the PDP context(s) and returns a Delete PDP Context Response (TEID) message to the SGSN server.

3) The SGSN server sends the "SUBTRACT/MODIFY Request" message to remove the corresponding GTP tunnel end points in the PS-MGW. When the PS-MGW has done this, it returns the "SUBTRACT/MODIFY Response" message to the SGSN server.

If each of the GTP tunnel end points for every PDP context are set up in a separate H.248 Termination, the "SUBTRACT" command is used in this step. If the GTP tunnel end points on the same interface (Iu or Gn) are set up in the same H.248 Termination for all the PDP contexts sharing a given PDP address and APN, then the "MODIFY" command is used in this step, unless the Teardown Ind was included in the Delete PDP Context Request message. If the Teardown Ind was included, the "SUBTRACT" command is used.

4) The SGSN server returns a Deactivate PDP Context Accept (TI) message to the MS.

5) The radio access bearer release is done by the RAB Assignment procedure.

C1) CAMEL-GPRS-Deactivate-PDP-Context

6.3.2.6 Iu Release Procedure
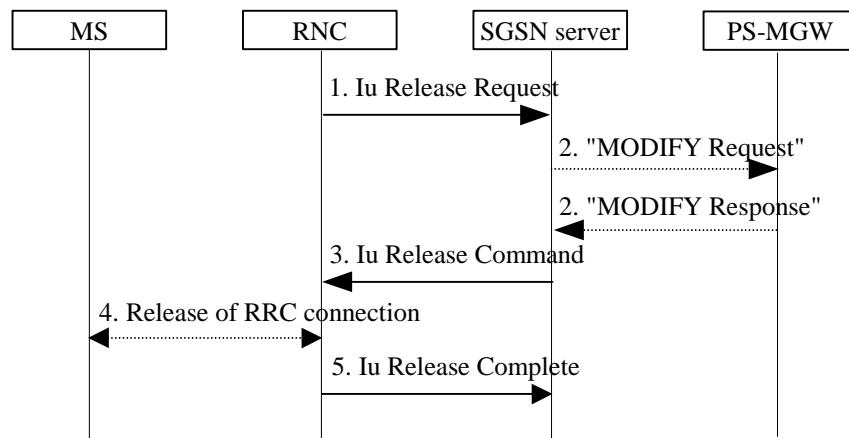
Figure 15: Iu Release Procedure

1) The RNC sends an Iu Release Request message to the SGSN server.

2) The SGSN server sends the "MODIFY Request" message to the PS-MGW to remove the TEID(s) and the IP address(es) that the PS-MGW requires for communication towards the RNC. The maximum bit rate is included in this message to downgrade it to 0 kbit/s for both uplink and downlink in the PS-MGW. An Event is set to request the PS-MGW to inform the SGSN server when downlink PDP PDUs again are received from the GGSN. This is done for each of the PDP contexts for the MS.

   The PS-MGW returns the "MODIFY Response" message.

3) The SGSN server sends an Iu Release Command message to the RNC.

4) The RRC connection is released if still existing.

5) The RNC confirms the Iu release by sending an Iu Release Complete message to the SGSN server for each released RAB. The GTP SND and the GTP SNU are included to enable the SGSN server to restore the values in case the PDP context is maintained and the RAB is re-established at a later stage.

6.3.2.7 Service Request Initiated by MS Procedure
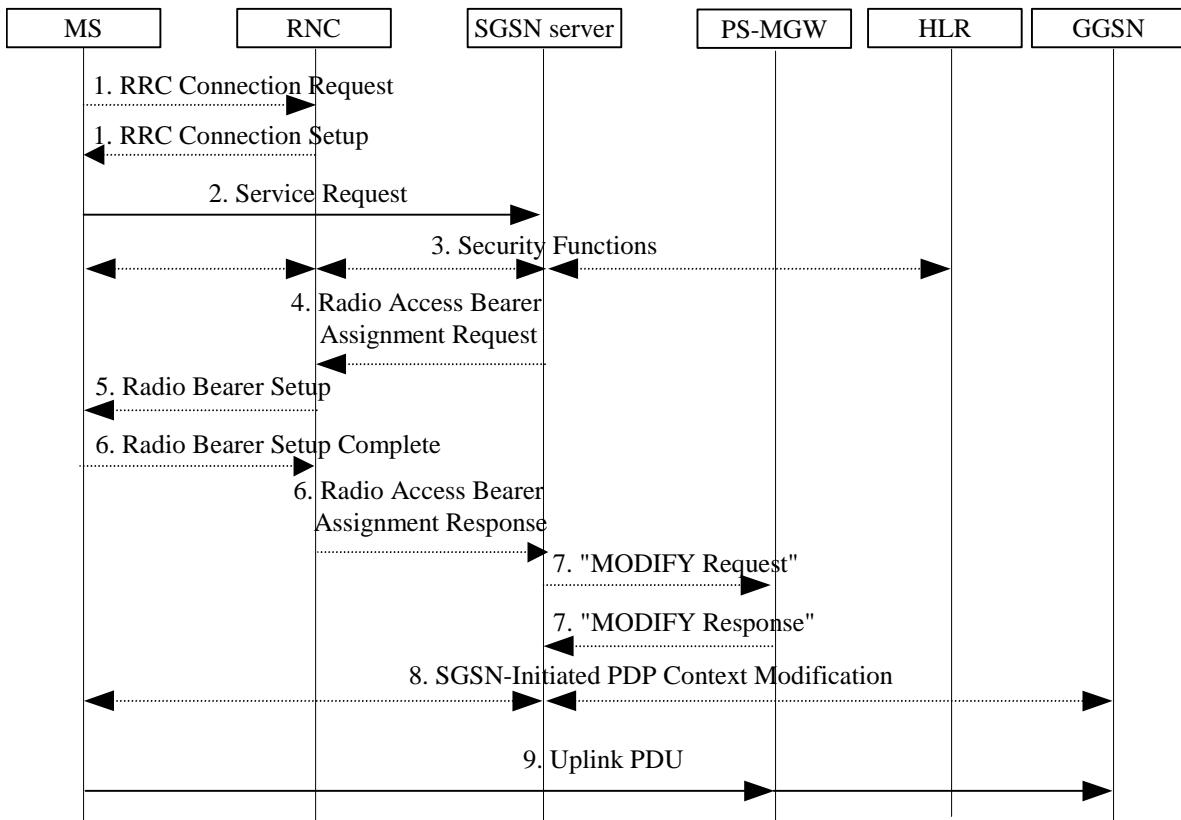
Figure 16: Service Request Initiated by MS Procedure

1) The MS establishes an RRC connection if none exists for CS traffic.

2) The MS sends a Service Request message to the SGSN server.

   If Service Type indicates Data, then a signalling connection is established between the MS and the SGSN server, and resources for active PDP context(s) are allocated, i.e. RAB establishment for the activated PDP context(s).

   If Service Type indicates Signalling, then the signalling connection is established between the MS and the SGSN server for sending upper-layer signalling messages.

3) The SGSN server shall perform the security functions if the service request was initiated by an MS in PMM-IDLE state.

4) In case Service Type indicates Data, the SGSN server sends a Radio Access Bearer Assignment Request message to re-establish radio access bearer for the activated PDP context(s). The TEID and the IP address that the RNC requires for communication towards the PS-MGW, for each of the activated PDP contexts, are included in this message.

5) The RNC indicates to the MS the new Radio Bearer Identity established and the corresponding RAB ID with the RRC radio bearer set up procedure.

6) The SRNC responds with the Radio Access Bearer Assignment Response message. The TEID and the IP address that the PS-MGW requires for communication towards the RNC, for each of the activated PDP context, are included in this message.

7) The SGSN server sends the "MODIFY Request" message to the PS-MGW with the TEID(s) and the IP address(es) that the PS-MGW requires for communication towards the RNC. Also the QoS attributes are included in this message. The Event, which was set to request the PS-MGW to inform the SGSN server when downlink PDP PDUs again are received from the GGSN, is deactivated. This is done for all the active PDP contexts for the MS.

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'The PS-MGW returns the "MODIFY Response" message.

`*[Note: see the note on QoS handling in the subclause "PDP Context Activation Procedure".]*

8) For each RAB re-established with a modified QoS profile, the SGSN server initiates a PDP Context Modification procedure to inform the MS and the GGSN of the new negotiated QoS profile for the corresponding PDP context.

9) The MS sends the uplink packet.

6.3.2.8 Service Request Initiated by Network Procedure
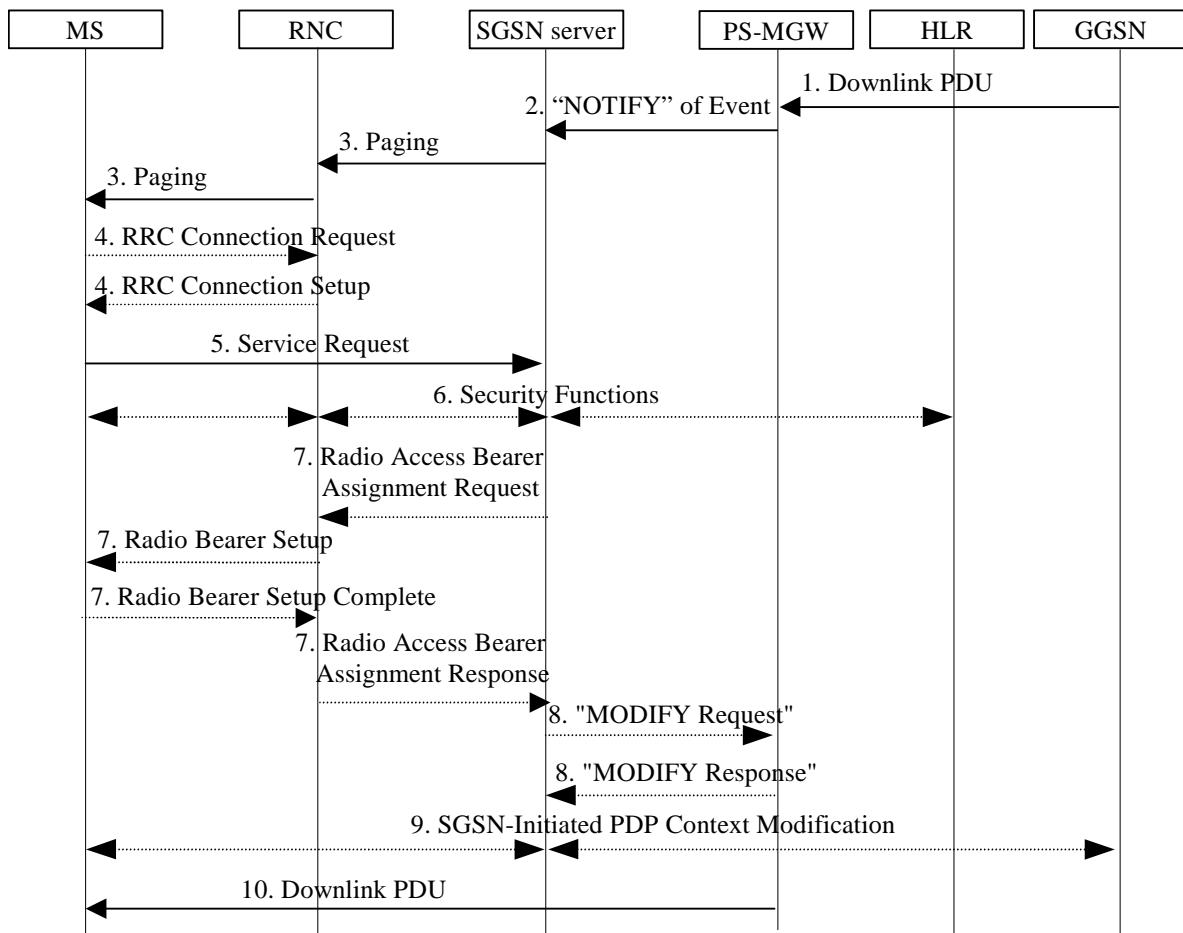
Figure 17: Service Request Initiated by Network Procedure

1) The PS-MGW receives a downlink PDP PDU for an MS in PMM-IDLE state.

2) The PS-MGW sends the "NOTIFY" message to the SGSN server to indicate that the previously set Event (inform upon reception of downlink PDP PDU) is encountered for the PDP context.

3) The SGSN server sends a Paging message to the RNC. The RNC pages the MS by sending a Paging message to the MS.

4) The MS establishes an RRC connection if none exists for CS traffic.

5) The MS sends a Service Request message to the SGSN server. Service Type specifies Paging Response.

6) to 9)   Similar to "Service Request Initiated by Network Procedure".

10) The PS-MGW sends the downlink packet.

6.3.3 Charging (H.248 option)

Today there is no requirement on spatial accuracy of charging data. However, such a requirement is easily remedied by letting the SGSN server read from the PS-MGW the data belonging to one area and to reset the counting and the Event when moving between areas. This can be done by means of existing H.248 mechanisms.

> NOTE: The load due to the transfer of the charging related information from the PS-MGW to the SGSN server is dependent upon the "Availability" of the PS-MGW platform. If the PS-MGW is a low availability platform, the charging related information is required to be sent more often, which increases the load on the Mp interface.

6.3.3.1   Handling of S-CDR

The data handled in the S-CDR are both based on control plane layer functionality (e.g. control layer signalling parameters) and user plane traffic (e.g. transferred volume).

The PS-MGW will transfer the parameters contained within the user plane to the SGSN server when required (Event based). The list of traffic data volumes that the PS-MGW must supply is split into containers which each includes the following fields: Data Volume Uplink, Data Volume Downlink, Change Condition, Cause for Closing and Time Stamp. Since a change of the QoS attributes or the occurrence of a tariff switch will cause the storing of a new container in the PS-MGW, the PS-MGW must have the knowledge of the tariff switch times and the QoS changes. Whenever such a container is stored, the counting (of volume counters) is started from zero again. Also, the PS-MGW knows the cause for closing the container (DataVolumeLimit, TimeDurationLimit and MaxNoOfChangesInChargingConditions), and must therefore supply this information. The rest of this functionality is handled in the SGSN server. This includes the handling of the CDR itself and the calculation of the time duration for the CDR. Alternatively, an external node connected to the SGSN server can transfer the CDRs to the Billing System.

> [Note that the above mentioned Tariff Switch Time will be a node property in the PS-MGW. This can either be provisioned in the PS-MGW by having it configured through O&M, or it can be defined in an H.248 package on the PS-MGW level. Hence, it is not required to signal this parameter for every PDP context.]

Conditions are defined for when charging data must be recorded and sent for storage or output. The possible conditions are at volume threshold reached, at time threshold reached and at maximum number of changes in charging conditions. (A change in charging condition occurs at a QoS change and at a tariff switch change). An H.248 Event will be defined to handle this in a split architecture. The SGSN server will then send this Event to the PS-MGW during the activation of the PDP contexts. The Event will indicate under which conditions the PS-MGW must send the data to the SGSN server, and it will define the parameters to send to the SGSN server. Also, the package that defines the Event will describe when the charging counters are set to zero and counting is again started. This means that the charging counters are not cumulative. Note that the volume threshold and the time threshold indicating when to report to the SGSN server, will be the sum of volume and time respectively of all containers not yet reported to the SGSN server (in addition to the current interval). After the PS-MGW has informed the SGSN server of a reached threshold, the PS-MGW will again activate the Event.

> [Note that this Event should be 'permanently' active, and this requires some additional work on the H.248 specification. 'Permanently' active means that the SGSN server should not have to re-activate the event after every notification of the Event from the PS-MGW to the SGSN server.]

The following figure shows the required H.248 signalling for the case when a volume threshold is reached, and the PS-MGW is configured to report this to the SGSN server. The volume counters must also be sent to the SGSN server when the PDP context is deactivated.

Sequences for other conditions for which the SGSN server must be notified are virtually the same, only that e.g. a time threshold initiates the H.248 reporting instead of a user plane packet.
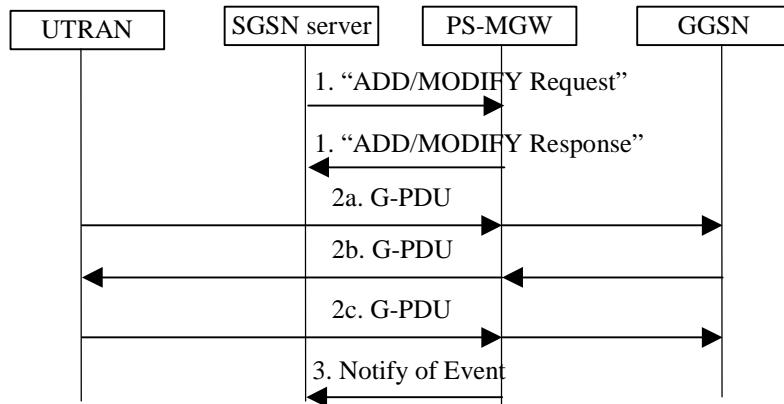
Figure 18: Sequence for transferring user plane data from the PS-MGW to the SGSN server

1) At PDP Context activation, the SGSN server sends an Event to the PS-MGW to indicate when the PS-MGW must report back to the SGSN server. The Event will be set in e.g. the first message going from the SGSN server to the PS-MGW, and will hence not require a separate message. In case of e.g. a subscription change, this can also be signalled in a separate message. This means the Event can be set in the "ADD Request" message (the H.248 Termination handling the Event did not exist) or in the "MODIFY Request" message (the H.248 Termination handling the Event already existed).

   The PS-MGW returns the "ADD/MODIFY Response" message.

   [Note that this Event could alternatively be specified as two separate Events, one giving the time threshold and the other giving the volume threshold.]

2) G-PDUs are transferred in one or both directions.

3) The PS-MGW discovers that the volume threshold is reached, and it therefore provides the required data to the SGSN server. The Event for the next reporting is reset, and counting is started from zero again.

6.3.3.2 Handling of other types of CDRs in the SGSN server

The other types of CDRs handled by SGSN are:

- M-CDR

- S-SMO-CDR

- S-SMT-CDR

These contain only data from control signalling messages and data that is stored in the SGSN server. Therefore these CDRs are handled in the SGSN server.

6.3.3.3 Handling of prepaid on-line

Prepaid on-line charging is always CAMEL based for GPRS. Since the CAMEL based charging will be Event based on the Mp interface, the charging information will be reported in real time to the SGSN server. For this reason, prepaid does not add any complexity to the split of the SGSN, but requires fast processing. See chapter 0 "CAMEL considerations" for more information on how CAMEL is solved.

6.3.3.4 Handling of hot-billing

Hot-billing is CDR based charging in GPRS, with the additional requirement of being able to output the CDRs relatively quickly. Since the CDR based charging will be Event based on the Mp interface, the charging data will be reported in real time to the SGSN server. For this reason, hot-billing does not add any complexity to the split of the SGSN.

6.3.3.5 General charging issues on the Mp interface

Charging data will be reported from the PS-MGW to the SGSN server per PDP context, and it is possible to set thresholds for when to do this reporting. In order not to overload the Mp interface, it is important to take some caution when setting the conditions for reporting. However, as the thresholds are set from the SGSN server, the SGSN server has the possibility to tune the amount of signalling due to the reporting.

6.3.4 CAMEL Considerations (H.248 option)

6.3.4.1 Handling of Volume Based CAMEL Charging

For CAMEL, the SCF has the possibility to individually set both a volume threshold and a time threshold on PDP context level. The time threshold gives a relative time for when to report back to the SCF, while the volume threshold gives a number of octets (in the user plane packets) to monitor for before reporting back to the SCF. The number of octets is the sum of sent and received octets. These two thresholds are closely connected in the way that both the time and the volume must be reported upon reaching one of the thresholds. Upon reporting, both the counter and the clock will be reset and start from zero. The new thresholds to monitor for will be supplied from the SCF when the SCF receives a threshold report. If the SCF decides to release the PDP context, new thresholds are not supplied.

Since the PS-MGW has the knowledge of the transferred volume and due to the close connection between monitoring for volume and time thresholds on PDP context level for CAMEL, the PS-MGW will need the capability to monitor for both of these. An Event will be defined for this in H.248. Alternatively, two Events could be specified; one for the time threshold and one for the volume threshold.

Alternatively, it is possible to do the time monitoring in the SGSN server. H.248 allows for getting hold of the volume counters and resetting the Event in the PS-MGW when the time threshold is reached. If the volume threshold is reached first, the volume counters are reported to the SGSN server. The SGSN server must then read the elapsed time and reset the clock again before reporting both volume and time to the SCF.

The SCF might also include a tariff switch time on PDP context level (which is not connected by any mean to tariff switch times for CDR generation). The SGSN server will forward the tariff switch time for the PDP context to the PS-MGW by means of the same Event giving the thresholds. (If the SGSN server is monitoring for the time threshold, it must also itself store the tariff switch time.) At the tariff switch, no reporting is done. The PS-MGW only stores the current value of the counter and the clock (if both monitoring for time and volume thresholds is applicable), and the counter/clock is started from zero again. Note that the thresholds to look for are the sum of the counters/clocks before and after the tariff switch.

Both time and volume is reported at a change of QoS attributes (if both are monitored), and the counter/clock is started from zero again. As always after having reported to the SGSN server, new thresholds are awaited from the SCF via the SGSN server.

For simplicity, the required signalling for setting up the PDP context is omitted in the below figure.
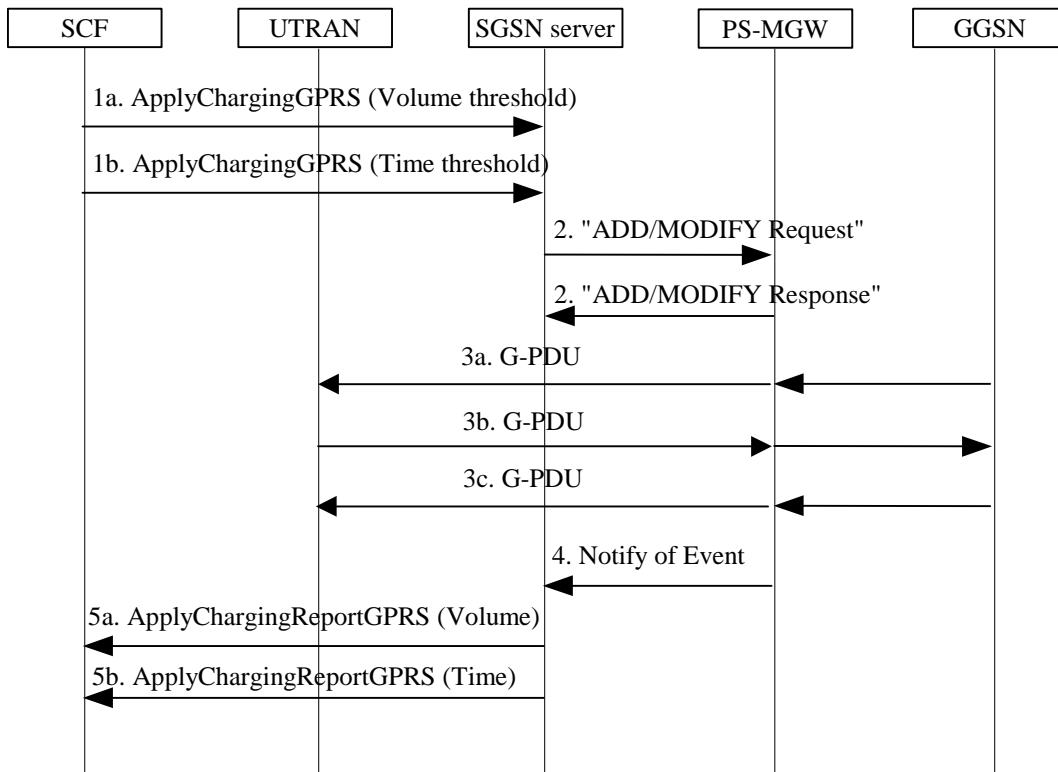
Figure 19: Sequence for reaching volume threshold for CAMEL based charging

1) The SCF sends a volume threshold and a time threshold in two separate ApplyChargingGPRS messages.

2) The SGSN server sends an Event to the PS-MGW to indicate when the PS-MGW shall report back to the SGSN server, i.e. when a specific volume threshold or a time threshold is encountered. In case the Event is sent to the PS-MGW during the PDP context activation, the Event can be signalled in an existing message and hence a separate message is not required to signal this Event. In case the Event is sent at a later point of time, a separate message may be needed. The event can either be sent in the "ADD Request" message (the H.248 Termination handling the Event did not exist) or in the "MODIFY Request" message (the H.248 Termination handling the Event already existed).

   The PS-MGW returns the "ADD/MODIFY Response" message.

3) G-PDUs are transferred in one or both directions.

4) The PS-MGW discovers that the volume threshold is reached, and it therefore notifies the SGSN server of the time and the volume reached. Also, the clock and the counter are reset to zero and started again. New thresholds are awaited supplied from the SCF via the SGSN server.

5) The SGSN server sends the volume reached and the time reached in two separate ApplyChargingReportGPRS messages. The SCF can now supply new thresholds, and the sequence is repeated from step 1).

6.3.4.2 Handling of Time Based CAMEL Charging

Thresholds for time based CAMEL charging on PDP context level will be possible to monitor in the PS-MGW, as this threshold is closely connected to the volume threshold supplied from the SCF (via the SGSN server). Alternatively, this time monitoring is possible to perform from the SGSN server as described in the previous chapter. The SGSN server will know when to act, e.g. a change of the QoS attributes has occurred, a tariff switch has occurred, or a volume limit is reported from the PS-MGW.

Thresholds for time based CAMEL charging on CAMEL session level are completely decoupled from volume counting. Therefore the SGSN server will keep the control of this time threshold, when applicable. A CAMEL session is started at attach and ended at detach.

6.3.5 Lawful Interception (H.248 option)

6.3.5.1 Lawful Interception of Content of Communications

To enable the PS-MGW to intercept Content of Communication (CC), or in other words user plane packets, and forward these to Delivery Function 3 (DF3), the SGSN server must order the PS-MGW to set up a one way connection towards DF3 for every applicable PDP Context. The SGSN server must give the PS-MGW the parameters that are necessary to set up these one way connections, and the parameters that the PS-MGW must insert into the intercepted packets.

In the current lawful interception specification (3GPP TS 33.107) it is an option to have the DF3 co-located with the SGSN. When the SGSN is split into an SGSN server and a PS-MGW, the DF3 should not be co-located with the PS-MGW. If this was an option, extra functionality would be required at the Administration Function (ADMF) and at the SGSN server in order to know which of the PS-MGWs have a co-located DF3 and which PS-MGWs are stand alone.

In case security is required at the interface between the PS-MGW and the SGSN server, this should be provided on transport level for all communications. There should not be specific security for the lawful interception function on this interface.

In case security is required at the interface between the PS-MGW and the DF3, this should be provided on transport level.

The below figure shows the sequence for setting up the one way connection towards DF3, and the forwarding of intercepted CC. The set up of the PDP contexts for the MS is not shown in the figure as this is irrelevant for the interception of CC, and also this will be identical to the PDP Context Activation procedure described in chapter 0 "Session Management".
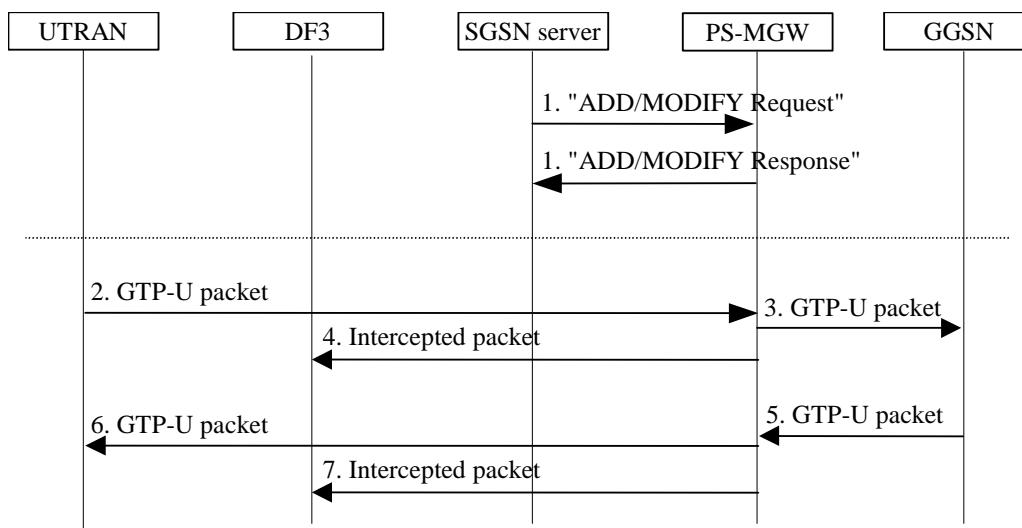
Figure 20: Lawful Interception of CC

1) The SGSN server sends the "ADD/MODIFY Request" message to the PS-MGW to order set up of a communication path towards DF3, when the CC must be intercepted for this PDP context. This message will contain the Destination Address of the DF3, the Target ID, the Correlation Number and the Target Location or the Interception Area in case of location dependent interception.

   The PS-MGW returns the "ADD/MODIFY Response" message to the SGSN server.

   If each of the 'tunnel end points' towards DF3 is set up in a separate H.248 Termination for every PDP context, the "ADD" command is used in this step. If the 'tunnel end points' going towards the same external address (here, the one towards the DF3) are set up in the same H.248 Termination for all the PDP contexts sharing a given PDP address and APN, then the "MODIFY" command can be used in this step. (The "ADD" command is used if this was the first PDP context to be monitored, or if several PDP contexts were requested to be monitored at the same time.)

2) A GTP-U packet is received from the UTRAN.

3) The GTP-U packet is forwarded to the GGSN.

4) The intercepted packet is modified in the format required by the DF3 and is sent to the DF3.

5) A GTP-U packet is received from the GGSN.

6) The GTP-U packet is forwarded to the UTRAN.

7) The intercepted packet is modified in the format required by the DF3 and is sent to the DF3.

When the lawful interception is terminated, the SGSN server sends a "MODIFY/SUBTRACT Request" message, and the PS-MGW responds with a "MODIFY/SUBTRACT Response" message. The SUBTRACT is used if the whole H.248 Termination is released. The MODIFY is used if monitoring of one PDP context is terminated while the H.248 Termination still intercepts packets on other PDP contexts.

6.3.5.2 Lawful Interception of Intercept Related Information

The IRI (Intercept Related Information) is control layer signalling, and therefore this must be handled in the SGSN server.

6.3.6 QoS Considerations (H.248 option)

The QoS aspects in the split architecture when the resource situation is of no concern are already handled in 0 Mobility Management and 0 Session Management.

The PS-MGW should inform its SGSN server(s) about the load situation in the PS-MGW. Work is ongoing in H.248 standardisation to solve the issues of overload and congestion handling. The PS domain of 3GPP should take advantage of this work and adopt the same solutions.

6.3.7 Abnormal Cases (H.248 option)

Existing procedures will be used as far as possible. In the H.248 standardisation area, the PS domain of 3GPP should take advantage of existing work ongoing in the CS domain of 3GPP. More specific this means the following:

The Echo Request and the Echo Response messages will be used to discover link failure between user plane nodes, to discover link failure between control plane nodes, and to discover restart in a control plane peer node. This is done according to the current 3GPP specifications.

A package using existing H.248 mechanisms will be defined to enable the SGSN server to have the control and be informed of link failures in the user plane.

To handle link failures on the Mp interface, restarts in the PS-MGW, and restarts in the SGSN server, the PS domain of 3GPP should adopt the solutions decided in the ongoing work on the CS domain of 3GPP.

When the PS-MGW is upgraded with new capabilities (e.g. new hardware which supports additional QoS), the PS-MGW should be able to inform the SGSN server of the new capabilities. In H.248 the ServiceChange command can perform this role.

When H.248 is used on the Mp interface, an Event can be specified to enable the PS-MGW to inform the SGSN server of received Error Indication messages. The SGSN server will then initiate release of the PDP context.

6.4 GTP-C option over Mp

NOTE: Two options are considered in this TR as to the protocol to use over the Mp interface; H.248 with extensions and GTP-C with extensions. Both options are described for comparison purposes, however only one of them shall eventually be retained. The protocol selection might be deferred to the stage 3 work.

6.4.1 Mobility Management (GTP-C option)

The SGSN split does not have effects on the Mobility Management procedures for attach and detach, security and subscriber management. The location management procedures (i.e. the routing area update and the serving SRNS relocation procedures) and the Service Request procedures are affected. The changes are not major. The traffic in the backbone network is, however, increased due to signalling between the SGSN Server and the PS-MGW.

6.4.1.1 Routing Area Update Procedure

At inter SGSN routing area update, the PDP context information is transferred from the old SGSN Server to the new SGSN Server. The PS-MGW may be changed or preserved.

If the PS-MGW is changed, the PDP contexts are created in the new PS-MGW and deleted in the old PS-MGW. The inter SGSN routing area update procedure with the required changes is presented in the figure below.
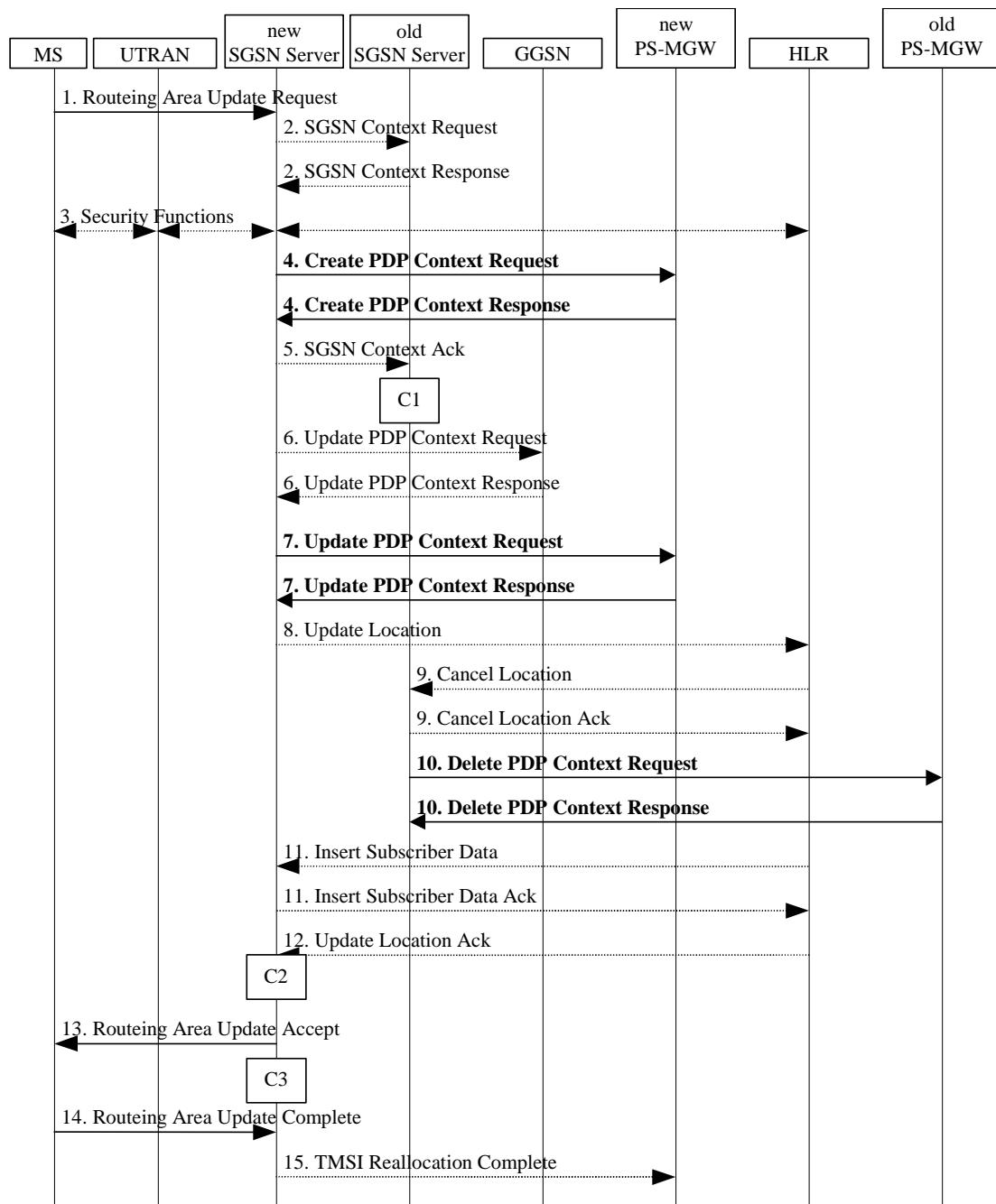
Figure 21: UMTS RA Update Procedure

1-3)   The routing area update procedure is performed as described in 23.060.

4)   After transferring the PDP context(s) from the old SGSN Server to the new SGSN Server, the new SGSN Server sends the Create PDP Context Request (TEID Signalling, QoS Negotiated, NSAPI, Charging Characteristics) message for every PDP context to the new PS-MGW. The new PS-MGW performs admission control, creates the PDP context and acknowledges by sending the Create PDP Context Response (TEID Signalling, QoS Negotiated, SGSN Address, SGSN TEID Data, Cause) message to the new SGSN Server.

5-6)   The routing area update procedure is continued as described in 23.060.

7)   The new SGSN Server sends the Update PDP Context Request (TEID Signalling, NSAPI, GGSN Address, GGSN TEID Data) message to the new PS-MGW to update the PDP context with the GGSN Address and the GGSN TEID Data. The new PS-MGW acknowledges by sending the Update PDP Context Response (TEID Signalling, Cause) message to the new SGSN Server.

8-9)   The routing area update procedure is continued as described in 23.060.

10) After receiving a request from the HLR to delete the PDP context(s), the old SGSN Server sends the Delete PDP Context Request (TEID Signalling, NSAPI, Teardown Ind) message to the old PS-MGW. The old PS-MGW deletes the PDP context(s) and acknowledges by sending the Delete PDP Context Response (TEID Signalling) message to the old SGSN Server.

11-15) The routing area update procedure is continued as described in 23.060.

Preserving the PS-MGW when changing the SGSN Server introduces more complexity to the routing area update procedure and is FFS.

6.4.1.2   Serving SRNS Relocation Procedure

If the SGSN Server is changed at serving SRNS relocation, the PDP context information is transferred from the old SGSN Server to the new SGSN Server. The PS-MGW may be changed or preserved.

If the PS-MGW is changed, the PDP contexts are created in the new PS-MGW and deleted in the old PS-MGW. The serving SRNS relocation procedure with the required changes is presented in the figure below.
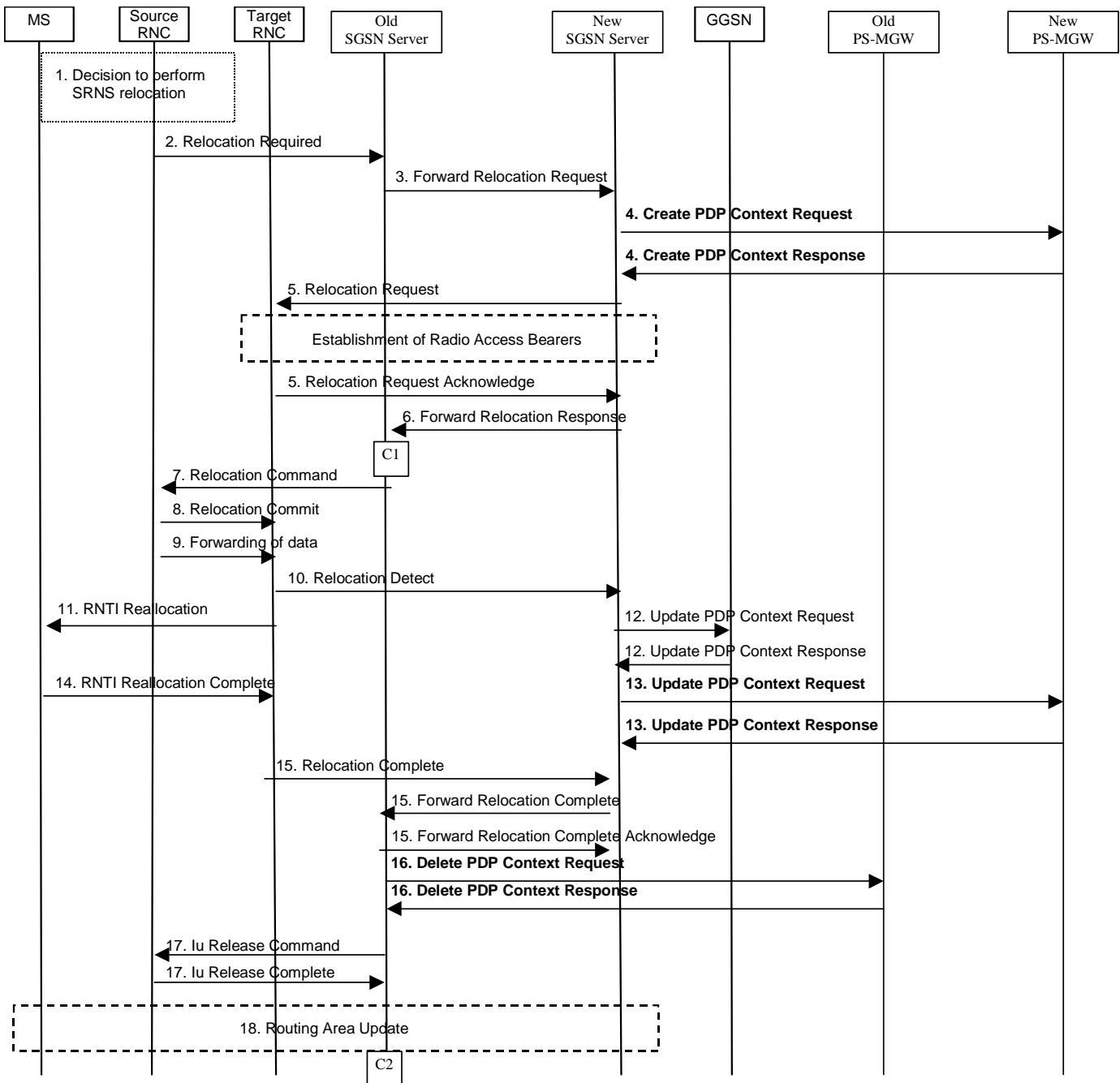
Figure 22: Serving SRNS Relocation procedure

1-3)   The serving SRNS relocation procedure is performed as ` ignallin in 23.060.

4)   After transferring the PDP context(s) from the old SGSN Server to the new SGSN Server, the new SGSN Server sends the Create PDP Context Request (TEID Signalling, QoS Negotiated, NSAPI, Charging Characteristics) message for every PDP context to the new PS-MGW. The new PS-MGW performs admission control, creates the PDP context and acknowledges by sending the Create PDP Context Response (TEID Signalling, QoS Negotiated, SGSN Address, SGSN TEID Data, Cause) message to the new SGSN Server.

5-12) The serving SRNS relocation procedure is continued as ` ignallin in 23.060.

13) The new SGSN Server sends the Update PDP Context Request (TEID Signalling, NSAPI, RNC Address, RNC TEID Data, GGSN Address, GGSN TEID Data) message to the new PS-MGW. The RNC Address and the RNC TEID Data are required to forward packets to the RNC, while the GGSN Address and the GGSN TEID Data are required to forward packets to the GGSN. The new PS-MGW updates the PDP context and acknowledges by sending the Update PDP Context Response (TEID Signalling, Cause) message to the new SGSN Server.

14-15) The serving SRNS relocation procedure is continued as ` ignallin in 23.060.

16) When the serving SRNS relocation is complete, the old SGSN Server sends the Delete PDP Context Request (TEID Signalling, NSAPI, Teardown Ind) message to the old PS-MGW. The old PS-MGW deletes the PDP context(s) and acknowledges by sending the Delete PDP Context Response (TEID Signalling) message to the old SGSN Server.

17-18) The serving SRNS relocation procedure is continued as ` ignallin in 23.060.

6.4.2 Session Management (GTP-C option)

Session Management is used for PDP context activation, modification and deactivation. All the procedures are affected by the SGSN split. The changes are not major. The traffic in the backbone network is, however, increased due to signalling between the SGSN Server and the PS-MGW.

6.4.2.1 PDP Context Activation Procedure

At PDP context activation, a PDP context is created in the PS-MGW. The PDP context is needed in the PS-MGW, e.g., to relay GTP-U packets between the RNC and the GGSN and to provide the negotiated QoS. The SGSN Server selects the PS-MGW to which the PDP context is created. The selection may be static (i.e. the SGSN Server always selects the same PS-MGW) or dynamic (i.e. the SGSN Server selects the PS-MGW from a group of PS-MGWs). In case of the dynamic selection, mechanisms for load balancing should be supported. The mechanisms to be supported are FFS.

The PDP context activation procedure with the required changes is presented in the figure below.
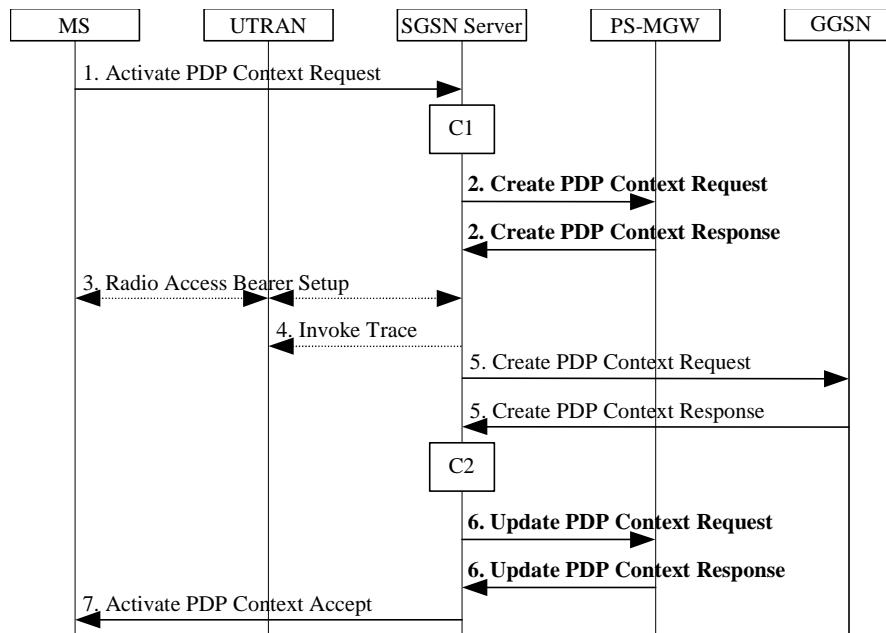
Figure 23: PDP Context Activation Procedure for UMTS

1) The PDP context activation procedure is performed as described in 23.060.

2) The SGSN Server sends the Create PDP Context Request (TEID Signalling, QoS Negotiated, NSAPI, Charging Characteristics) message to the PS-MGW. The PS-MGW performs admission control, creates the PDP context and acknowledges by sending the Create PDP Context Response (TEID Signalling, QoS Negotiated, SGSN Address, SGSN TEID Data, Cause) message to the SGSN Server.

3-5) The PDP context activation procedure is continued as described in 23.060.

6) The SGSN Server sends the Update PDP Context Request (TEID Signalling, NSAPI, RNC Address, RNC TEID Data, GGSN Address, GGSN TEID Data) message to the PS-MGW. The RNC Address and the RNC TEID Data are required to forward packets to the RNC, while the GGSN Address and the GGSN TEID Data are required to forward packets to the GGSN. The PS-MGW updates the PDP context and acknowledges by sending the Update PDP Context Response (TEID Signalling, Cause) message to the SGSN Server.

7) The PDP context activation is accepted.

6.4.2.2 PDP Context Modification Procedures

At PDP context modification, the PDP context in the PS-MGW is updated.

The MS initiated PDP context modification procedure with the required changes is presented in the figure below. The required changes are the same in case of the SGSN or GGSN initiated PDP context modification procedure.
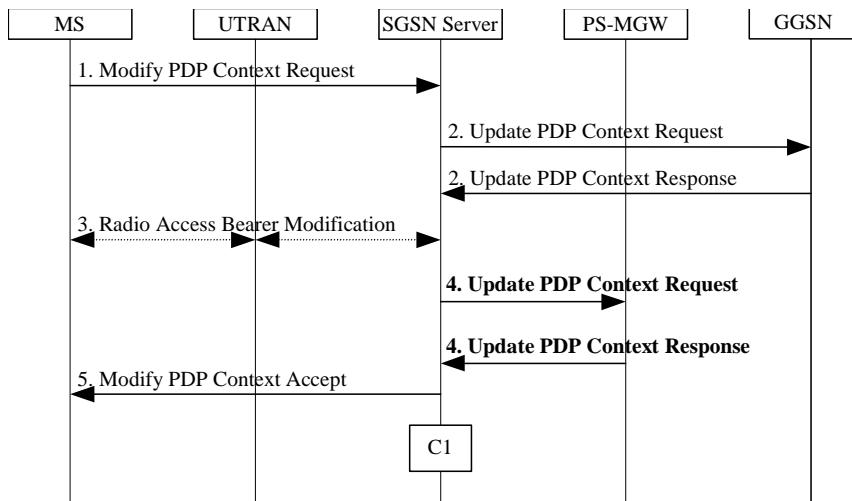
Figure 24: MS-Initiated PDP Context Modification Procedure for UMTS

1-3) The PDP context modification procedure is performed as described in 23.060.

4) The SGSN Server sends the Update PDP Context Request (TEID Signalling, NSAPI, QoS Negotiated, RNC Address, RNC TEID Data, GGSN Address, GGSN TEID Data) message to the PS-MGW. The PS-MGW performs admission control, updates the PDP context and acknowledges by sending the Update PDP Context Response (TEID Signalling, QoS Negotiated) message to the SGSN Server.

5) The PDP context modification is accepted.

6.4.2.3   PDP Context Deactivation Procedure

At PDP context deactivation, the PDP context in the PS-MGW is deleted.

The MS initiated PDP context deactivation procedure with the required changes is presented in the figure below. The required changes are the same in case of the SGSN or GGSN initiated PDP context deactivation procedure.
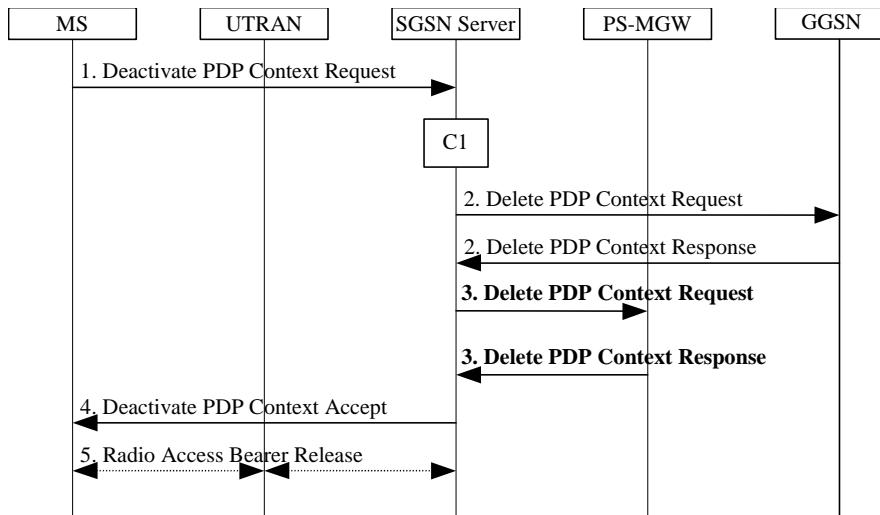
Figure 25: PDP Context Deactivation Initiated by MS Procedure for UMTS

1-2)   The PDP context deactivation procedure is performed as described in 23.060.

3)   The SGSN Server sends the Delete PDP Context Request (TEID Signalling, NSAPI, Teardown Ind) message to the PS-MGW. The PS-MGW removes the PDP context(s) and acknowledges by sending the Delete PDP Context Response (TEID Signalling) message to the SGSN Server.

4-5)   The PDP context deactivation procedure is continued as described in 23.060.

6.4.2.4 RAB Release Procedure

With the RAB release procedure, the UTRAN initiates the release of one or more RABs. The SGSN Server has to inform the PS-MGW about the RAB release. The RAB release procedure with the required changes is presented in the figure below.
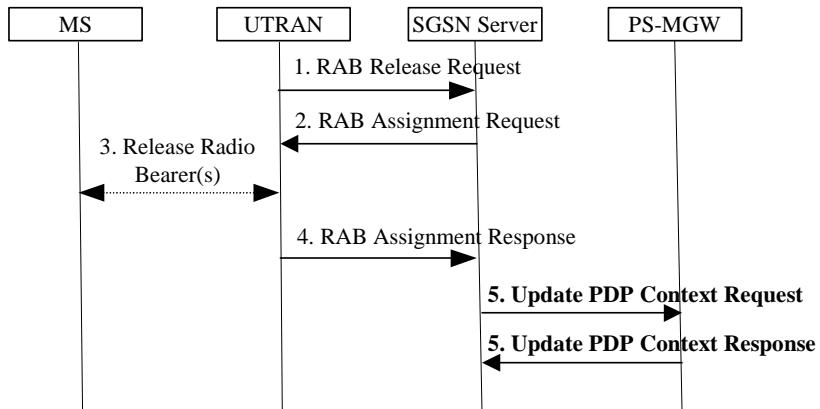
Figure 26: RAB Release Procedure

1-4)   The RAB release procedure is performed as described in 23.060.

5)   After the RAB(s) are released, the SGSN Server sends the Update PDP Context Request message for every PDP context in question to the PS-MGW to inform about the RAB release. The PS-MGW removes the RNC Address and the RNC TEID Data from the PDP context and acknowledges by sending the Update PDP Context Response (TEID Signalling, Cause) message to the SGSN Server.

6.4.2.5 Service Request Initiated by MS Procedure

After releasing RABs for active PDP contexts (see chapter 'RAB release'), it may be necessary to establish the RABs again, e.g., due to packets to be transferred on the PDP contexts. This is done with the service request procedure initiated either by the MS or by the network. The SGSN Server has to inform the PS-MGW about the establishment of the RABs. The MS initiated service request procedure with the required changes is presented in the figure below.
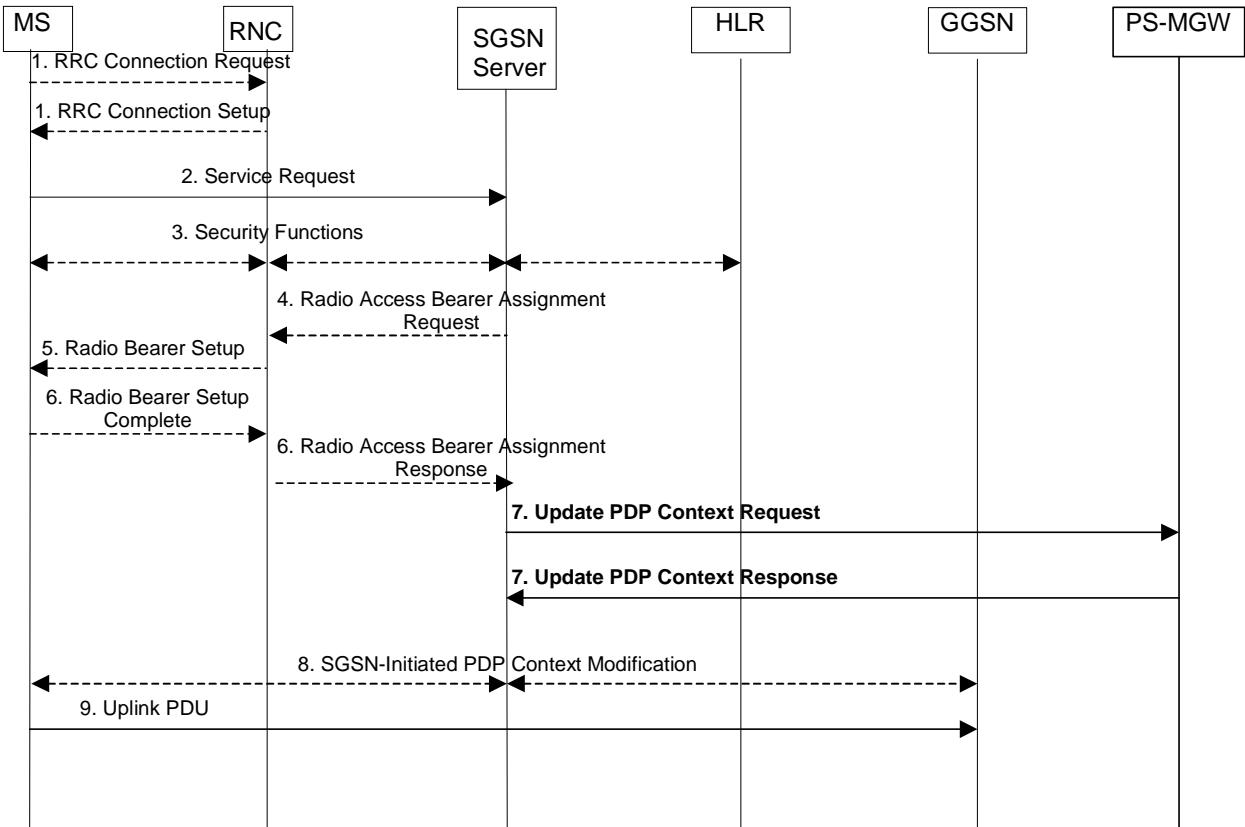
Figure 27: Service Request Initiated by MS Procedure

1-6) The service request procedure is performed as described in 23.060.

7) After RAB setup, the SGSN Server sends the Update PDP Context Request (TEID Signalling, NSAPI, RNC Address, RNC TEID Data) message for every PDP context in question to the PS-MGW. The PS-MGW updates the PDP context with the RNC Address and with the RNC TEID Data. The PS-MGW acknowledges by sending the Update PDP Context Response (TEID Signalling, Cause) message to the SGSN Server.

8-9) `The service request procedure is continued as described in 23.060.

6.4.2.6 Service Request Initiated by Network Procedure

The network initiated service request procedure with the required changes is presented in the figure below.
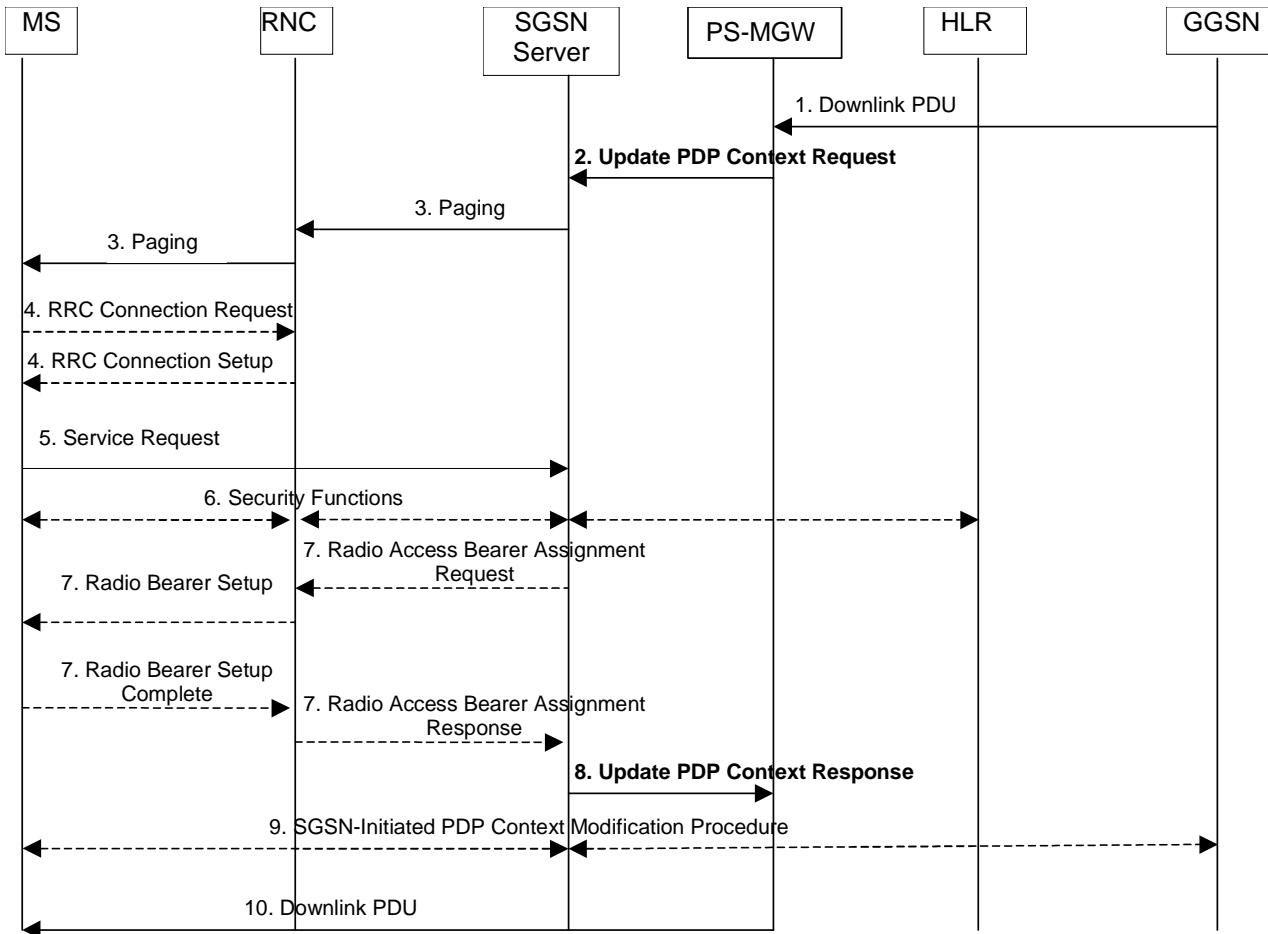
Figure 28: Service Request Initiated by Network Procedure

1) A downlink PDU is received in the PS-MGW.

2) The PS-MGW sends the Update PDP Context Request message to the SGSN Server to request the initiation of paging.

3-7) The service request procedure is continued as described in 23.060.

8) The SGSN Server sends the Update PDP Context Response (TEID Signalling, RNC Address, RNC TEID Data, Cause) message to the PS-MGW.

9-10) The service request procedure is continued as described in 23.060.

6.4.3 Charging (GTP-C option)

6.4.4 CAMEL Considerations (GTP-C option)

The communication towards the SCP is triggered by signalling events as well as by events related to the transfer of user data. The communication towards the SCP may be provided either by 1) preserving only one interface towards the SCP (i.e. SGSN Server – SCP) and sending the necessary information between the SGSN Server and the PS-MGW, or 2) standardising two interfaces towards the SCP (SGSN Server – SCP and PS-MGW – SCP).

In case of the alternative 1, the GTP-C can be modified to carry the necessary information. This alternative, however, increases signalling between the SGSN Server and the PS-MGW and may thus increase traffic in the backbone network significantly. Timing problems may also appear, because the communication towards the SCP happens in two phases:

PS-MGW – SGSN Server and SGSN Server – SCP or vice versa. For example, in case of data volume based prepaid, the PS-MGW sends reports on reaching a data volume threshold to the SGSN Server, which in turn sends the reports to the SCP. This is presented in the figure below. The figure presents an example, in which the data volume counting in the PS-MGW is started immediately at PDP context activation. If the account in the SCP becomes empty, there is additional delay before the PDP context can be deleted in the PS-MGW.
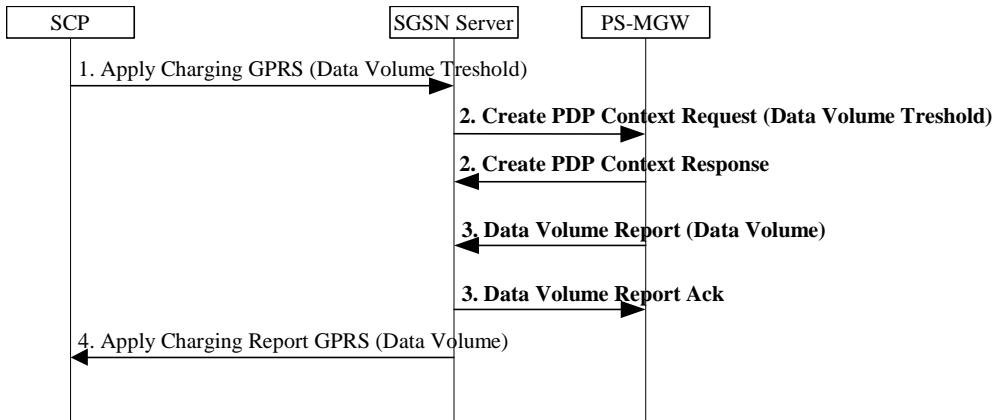
Figure 29: Volume based charging for CAMEL

The alternative 2 introduces more complexity to the PS-MGW, because the PS-MGW has to support CAP. This alternative may also affect the SCP and CAP. The effects of the alternative 2 are FFS.

6.4.5 Lawful Interception (GTP-C option)

6.4.5.1 Lawful Interception of Content of Communications

To enable the PS-MGW to intercept Content of Communication (CC), or in other words user plane packets, and forward these to Delivery Function 3 (DF3), the SGSN server must order the PS-MGW to set up a connection towards DF3 for every applicable PDP Context. The SGSN server must give the PS-MGW the parameters that are necessary to set up these connections, and the parameters that the PS-MGW must insert into the intercepted packets.

In the current lawful interception specification (3GPP TS 33.107) it is an option to have the DF3 co-located with the SGSN. When the SGSN is split into an SGSN server and a PS-MGW, the DF3 should not be co-located with the PS-MGW. If this was an option, extra functionality would be required at the Administration Function (ADMF) and at the SGSN server in order to know which of the PS-MGWs have a co-located DF3 and which PS-MGWs are stand alone.

In case security is required at the interface between the PS-MGW and the SGSN server, this should be provided on transport level for all communications.

For lawful interception, the Administration Function (ADMF) shall communicate with the SGSN Server. To enable the PS-MGW to intercept user packets (i.e. Content of Communication, CC), the SGSN Server must send a request to the PS-MGW for every PDP context in question. In the request, the SGSN Server sends the required parameters, containing e.g. needed triggering data, as conditional Ies of the GTP-C to the PS-MGW. The parameters are sent conditionally, i.e. when the PDP context is related to an observed target. Based on the parameters, the PS-MGW knows, e.g., which user packets are due to interception, and to which Delivery Function 3 (DF3) the PS-MGW should send the intercepted packets.

The following figure presents lawful interception initiation with GTP-C.
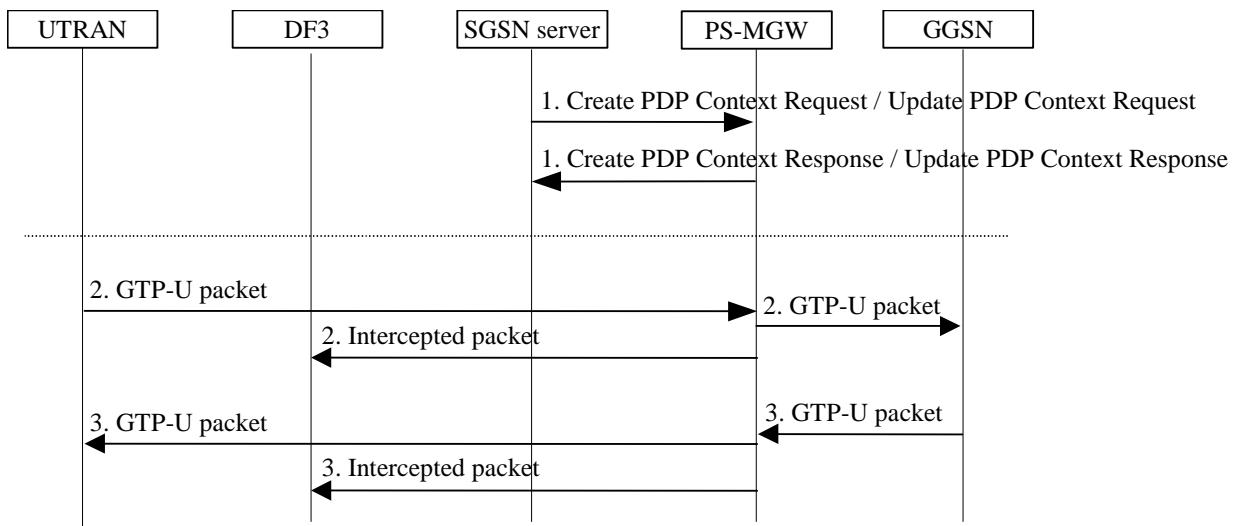
Figure 30: Lawful Interception of CC

1) The SGSN Server requests lawful interception initiation from the PS-MGW. The SGSN Server adds the parameters required for lawful interception to the Create PDP Context Request message or to the Update PDP Context Request message. The PS-MGW acknowledges by sending the Create PDP Context Response or the Update PDP Context Response message respectively.

2) The PS-MGW receives an uplink user packet for the PDP context due to interception. The PS-MGW sends the uplink user packet to the GGSN. For lawful interception, the PS-MGW sends the intercepted packet to the DF3.

3) The PS-MGW receives a downlink user packet for the PDP context due to interception. The PS-MGW sends the downlink user packet to the RNC. For lawful interception, the PS-MGW sends the intercepted packet to the DF3.

6.4.5.2   Lawful Interception of Intercept Related Information

The IRI (Intercept Related Information) signalling is handled by the SGSN server.

6.4.6   QoS Considerations (GTP-C option)

6.4.7   Information storage in PS-MGW (GTP-C option)

The PS-MGW has to store information on active PDP contexts in order to relay packets between the RNC and the GGSN. For uplink packets, the PS-MGW needs the GGSN Address for User Plane and the GGSN TEID for User Plane. For downlink packets, the PS-MGW needs the RNC Address for User Plane and the RNC TEID for User Plane.

For signalling towards the SGSN Server, the PS-MGW needs the SGSN Server TEID for Control Plane.

To perform QoS functions for user packets, the PS-MGW needs information on the negotiated QoS profile.

In order to perform charging functions, the PS-MGW needs information on the charging characteristics of the PDP context in question.

For CAMEL based prepaid services, the PS-MGW needs information on the data volume limit. When reaching the data volume limit, the PS-MGW sends a report to the SGSN Server.

The information set which have to be stored in the PS-MGW is presented in the table below.

Table 1: PS-MGW PDP context information

Field	Description
PDP Type	PDP type, e.g., PPP or IP.
PDP Address	PDP address, e.g., an IP address.
QoS Profile Negotiated	The quality of service profile negotiated.
GGSN Address for User Plane	The IP address of the GGSN currently used.
GGSN TEID for User Plane	Tunnel Endpoint Identifier towards the GGSN.
RNC Address for User Plane	The IP address of the RNC currently used.
RNC TEID for User Plane	Tunnel Endpoint Identifier towards the RNC.
SGSN Server TEID for Control Plane	Tunnel Endpoint Identifier for signalling towards the SGSN Server.
Uplink TEID for PS-MGW	Uplink Tunnel Endpoint Identifier for the PS-MGW end of the tunnel.
Downlink TEID for PS-MGW	Downlink Tunnel Endpoint Identifier for the PS-MGW end of the tunnel.
Charging Characteristics	The charging characteristics for this PDP context, e.g., normal, prepaid, flat-rate, and/or hot billing.
Data Volume Limit	The data volume limit used for CAMEL based prepaid services. The volume is measured in octets.
Charging ID	See TS 32.015. Identifies a PDP context per GGSN.
Location Information	RA, LAC and Cell Id of the MS. Can be used in charging.

6.4.8   Abnormal Cases (GTP-C option)

6.5   General Lawful Interception Considerations

As the protocol interfaces and data formats between the ADMF/DF and GSN entities were omitted from the scope of standardisation, constraints on the interoperability of the split SGSN exist, if the entities are to be supplied from different vendors. The ADMF and DF entities in this case would have to inter-operate with multiple vendors' proprietary interfaces. How the ADMF and DF entities would inter-operate with these proprietary interfaces is FFS.

When Rel99 SGSNs and SGSN servers from multiple vendors are deployed in the same network, further interoperability problems will become apparent as X1_1, X2 and X3 interface protocols and formats are not standardised.

3G TS 33.107 states, 'the correlation number is unique in the whole PLMN and is used to correlate CC with IRI and the different IRI's of one PDP context'. How this correlation number is derived is vendor specific and therefore cannot be guaranteed to be unique, when PS-MGWs and SGSN servers from different vendors are deployed in the same network. It is an open issue how the LI correlation issues could be handled properly in the SGSN Server – PS-MGW multivendor cases for the IRI and CC packet streams.

Additionally the security method used to encrypt the IRI and CC information, when the DF is remote, may differ, creating more inter-operability considerations.

As the IRI and CC information are now being delivered from separate entities, a failure of either entity would require additional signalling to be able to optimally handle the partial delivery of the LI data.

Failure recovery could also present further difficulties, as the ADMF would now have to attain synchronisation with two, rather than one, SGSN network entities, for a single intercepted target.

It is a general requirement in lawful interception that the CC would never be delivered without the IRI information. Therefore, if the X2 link from SGSN Server to DF2 failed, it is FFS how the CC information is delivered for the case where SGSN Server and PS-MGW are supplied from separate vendors.
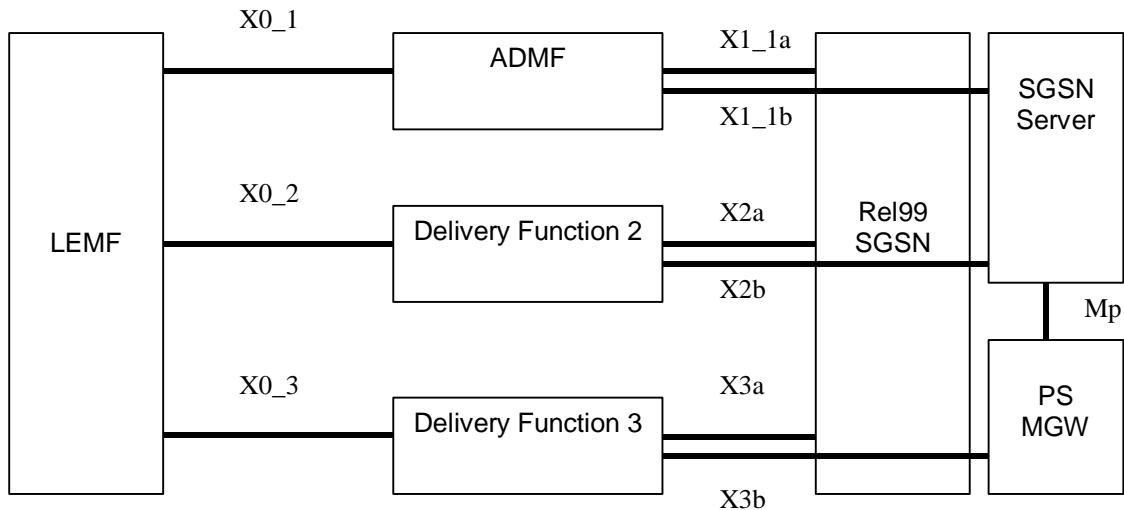
Figure 31: Lawful Interception interfaces in the case Rel99 and Split SGSN Entities with ADMF/DFs would co-exist in a network

6.6   Security

The security mechanisms Ipsec/IKE can be used on the Mp interface. Ipsec/IKE are recommended for the H.248 protocol and are parts of the security architecture that is under design in S3 for the UMTS R4/R5 network.

6.7   O&M

The split SGSN solution will add a new network element to manage but only minor changes to the 3GPP O&M standards.

6.8   RAN Considerations (e.g. GERAN)

No impacts are foreseen between the split of the SGSN and the RAN functionality since:

- The Iu-PS interface is already split into a control plane and a user plane, and the existing protocols can be used as is.

- The Gb interface will be terminated in the 2G-SGSN for both the control plane and the user plane.

- GERAN uses either the Iu-PS or the Gb interface.

6.9   Compatibility

The compatibility issue between 2G and 3G is already handled in the sections on Mobility Management.

As there is no impact on the existing PS protocols when introducing the split architecture, the SGSN server and the PS-MGW can have an interface towards R'97 (and later releases) nodes, both towards SGSN and GGSN.

6.10   Dynamic Allocation of PS-MGW Resources

A simple way of achieving resource sharing is that each SGSN server uses a primary PS-MGW and a secondary PS-MGW. Say SGSN server A uses PS-MGW A as its primary and PS-MGW B as its secondary, and SGSN server B uses PS-MGW B as its primary and PS-MGW A as its secondary. SGSN server A will therefore use PS-MGW A, and SGSN server B will use PS-MGW B when setting up all PDP contexts as long as resources are surplus.

Say now that PS-MGW A becomes loaded. It will then inform its SGSN servers of the situation by sending a Notify message. SGSN server A can now start using PS-MGW B for setting up PDP contexts, just like SGSN server B is doing. When the load of the PS-MGW A has dropped to a certain threshold, it can inform its servers that they again can start using it, by sending another Notify message. Therefore SGSN server A will use PS-MGW A for setting up new PDP contexts.

This shows that the ability to better utilise the total network capacity is increased in this case, as the alternative would be to reject the PDP context received in SGSN server A when the resources of PS-MGW A are scarce. This also shows that the split SGSN approach can be a clear advantage when the expected growth in user plane traffic occurs.

Note that this is just a simple example, yet many other more advanced scenarios can be conceived.

Work is ongoing in this area for the CS-domain, and the PS-domain should be able to adopt the same mechanisms in case H.248 is selected as the protocol on the Mp interface.

6.11 Benefits and Drawbacks

The benefits and drawbacks are compared to the R'99 architecture, unless otherwise specified.

Benefits:

- Flexibility to allocate processing capacity for traffic and for control in different locations

- Flexibility to independently scale the control plane and the user plane by increasing/decreasing the number of nodes required to handle the corresponding traffic. Nodes could in principle be supplied by different vendors.

- Allows an independent evolution and replacement of nodes in the user plane and the control plane (PS-MGW and SGSN server) as the corresponding technology evolves. Nodes could in principle be supplied by different vendors.

- As an implementation option it is possible to have a combined CS/PS MGW, which allows for an efficient allocation of resources amongst both domains (e.g. if the CS and PS logical instances of the MGW share some of the hardware resources like interface cards and lower layer protocols, the available bandwidth can be distributed between them as needed). Similar efficient allocation of bandwidth can be achieved when deploying non-combined CS/PS MGWs.

- As an implementation option it is possible to have an m:n relationship between SGSN servers and PS-MGWs, where each PS-MGW is connected to several SGSN servers and vice versa. This allows for an efficient allocation of user plane resources as the SGSN servers can setup new PDP contexts on another PS-MGW if one PS-MGW gets loaded. This will again lead to an increase of the ability to better utilise the total network capacity.

- Implementation options provide for greater network redundancy amongst network elements (node failure and network overload conditions).

Drawbacks:

- Not always applicable (2G radio)

- Increases standardisation and implementation work due to the new reference point Mp, including the control/management functionality between the SGSN server and the MGW. More vendor interoperability testing required for Iu and Mp interfaces and possibly for Lawful Interception.

- Increases signalling load due to the new interface Mp (PDP context creation, update and deletion, gateway control, reporting of charging data, Lawful Interception, Iu release, Service Request, intersystem change, suspend and resume operations). Implementation options of m:n relationship between SGSN servers and PS-MGWs could also generate additional signalling loads.

- Increases the time needed for signalling for some CAMEL based services, because there are more entities in the signalling path (i.e. PS-MGW – SGSN Server – SCP)

- Additional O&M interfaces are needed to configure and to operate the additional network entities

- Inter-system changes of the split architecture reduces the R99 advantages of co-locating 2G and 3G SGSNs.

- More redundancy schemes would be required to be in-built to the system due to more different partial system failure cases (when e.g. a SGSN Server node would go down but the MGW node not or vice versa).

6.12   Open Issues

- Investigation into redundancy schemes are to be addressed in stage 3 work

- Comparison analysis of H.248 and GTP-C protocols is to be addressed in stage 3 work

- Migration to MIP Step 3, as proposed by TR 23.923, would negate the need for the split architecture.

- Ongoing 3GPP work on Iu flexibility will allow load sharing between SGSNs, though with a potentially different level of granularity. The possible gains from sharing resources dynamically between PS-MGWs need to be evaluated against the Iu flexibility mechanism.

- Investigation into how the ADMF and DF entities can inter-operate for Lawful Interception when SGSN Server/PS MGW entities and/or Rel99 SGSN/SGSN Servers from separate vendors are deployed.

7   Alternative 2: One Tunnel Approach

7.1   Introduction

The One Tunnel Approach separates transport and control functionality of the SGSN in applicable scenarios. The result of this separation are an SGSN controller (cSGSN) performing all control functions of an SGSN and an enhanced GGSN (xGGSN) which performs SGSN and GGSN transport functionality. This enables a direct GTP tunnel between the Radio Access Network and the xGGSN. The One Tunnel Approach gains an improved efficiency by bypassing the SGSN. Additional network entities, like a PS-MGW, are not needed in this approach.

The One Tunnel Approach improves network efficiency and bearer service QoS for the bearer services that use a GGSN in the visited network by removing one PS domain specific core network node from the transport path when possible. This is the bearer service type best suited for the support of the IMS. It provides also high efficiency for most other users of IP bearer services. The efficiency is gained by less packet processing effort and less PS domain specific network nodes in the traffic path compared to the current R99 architecture. For the other bearer services requiring a GGSN outside the visited network or support of 2G GSM radio access or if either the SGSN or the GGSN is a R97-R99 node, the cSGSN performs also the transport functionality, therefore behaves like an SGSN.

The One Tunnel Approach allows a smooth migration as it is compatible with the R99 architecture by establishing 2 user plane tunnels in this case (i.e. the existing R99 procedures are used). It has no impact on the Radio Access Network and improves the architecture and IP bearer services when using GGSNs in the visited network. With the growing use of this bearer services (e.g. by the IMS) and a reduction in the use of other bearer service types as well as an upgrade of GSM RAN to GERAN the networks can migrate to the One Tunnel Approach only. If this is the only IP bearer service type used in a PLMN, i.e. the GGSNs are always in the visited network, and only 3G UEs and post-R99 GSNs are to be supported then the network architecture can completely base on this approach.

7.1.1   Applicability

The benefits of the approaches depend on the extent of their applicability. An anticipation of future IP bearer service usage is therefore important to identify the gain of the approaches.

The trends for the usage of IP bearer services anticipated here are:

- IP based VPN solutions provide access to Intranets in an access independent way (one access means are the PS IP bearer services). This avoids the need for GGSNs dedicated for the access to specific Intranets. Dynamic PDP contexts are sufficient.

- Roaming between ISPs in fixed networks is supported for example by RADIUS. The same is applicable for the PS CN resulting in more optimum routes by avoiding the tunnelling to ISP specific GGSNs potentially located in another network.

- A PLMN acting also as an ISP takes advantage from short tunnels and dynamic addresses by less user profile data and by more optimum routing. Also the resource efficiency is better because of less encapsulation overhead.

- The IMS as a main user of the IP bearer services requires high performance because all the IMS services base on the IP bearer service and the IMS has strong real time requirements for conversational services.

All these trends are best supported by short tunnels and dynamically allocated IP addresses, i.e. a GGSN in the visited network. The overall performance and especially the realtime requirements of the IMS benefit from a reduction in the payload processing effort for provision of the strong delay figures. The main usage of the PS CN anticipated here is therefore best supported by IP bearer services with dynamic IP addresses and with short tunnels ending in the visited PLMN. For this main case of IP bearer service usage the one tunnel approach described here provides its benefits.

The amount of roaming mobile user traffic is according to the U.K. Office of Telecommunications (Oftel) report November 2000 in U.K. 206 million call minutes roaming traffic coming inland of total 8388 million call minutes, i.e 2.5%, at the end of 1Q/2000. In Finland the figure for roaming traffic has been under 1%. And in an other country we can have a bigger percentage. Anyhow, in an average country the clear majority of the traffic is made so that the "point of access" is in the same country as the caller.
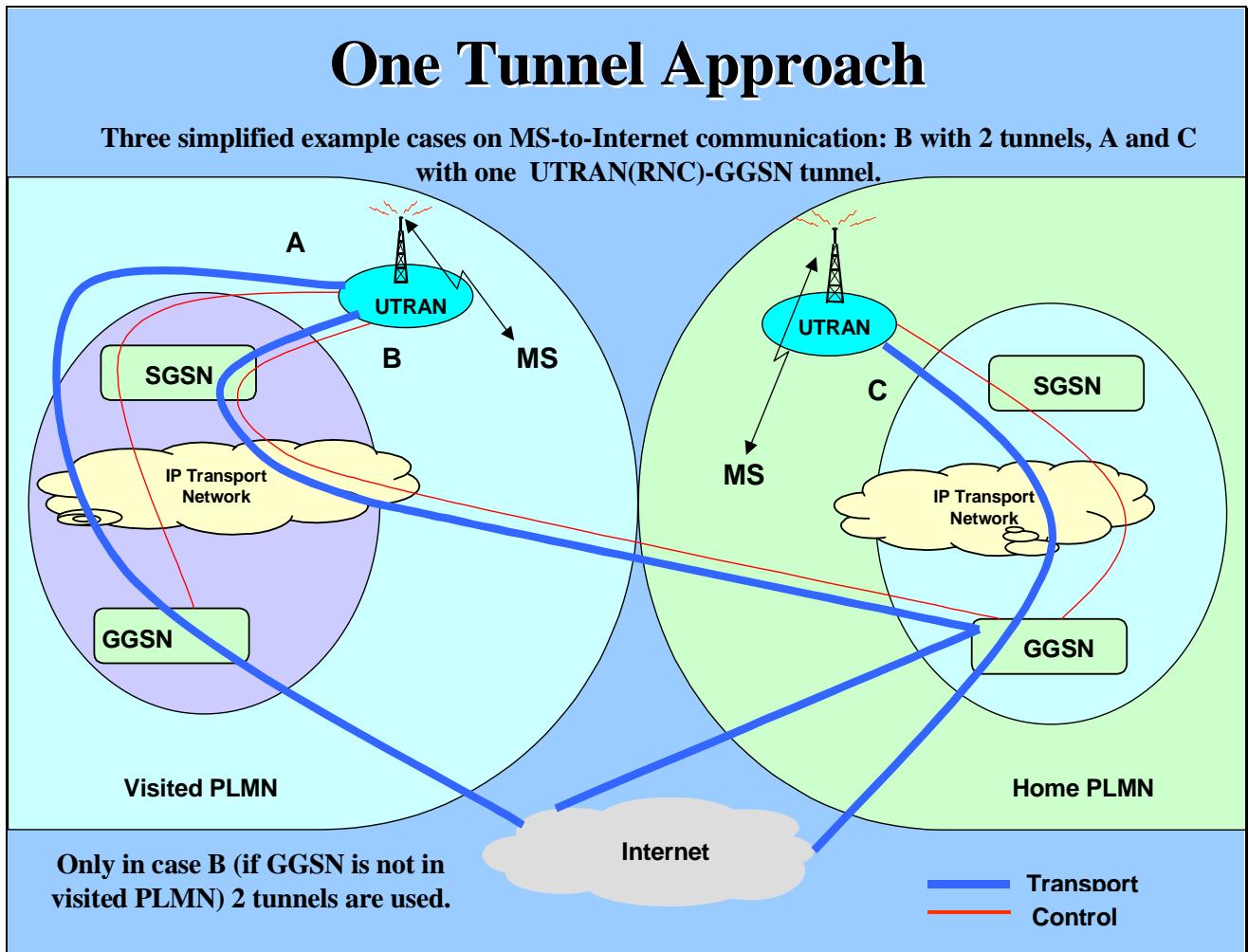
Figure 32: The One Tunnel approach in roaming scenarios

7.2 Logical Architecture

The logical architecture for this approach, as an evolution of the reference logical architecture, is depicted in Figure 33.
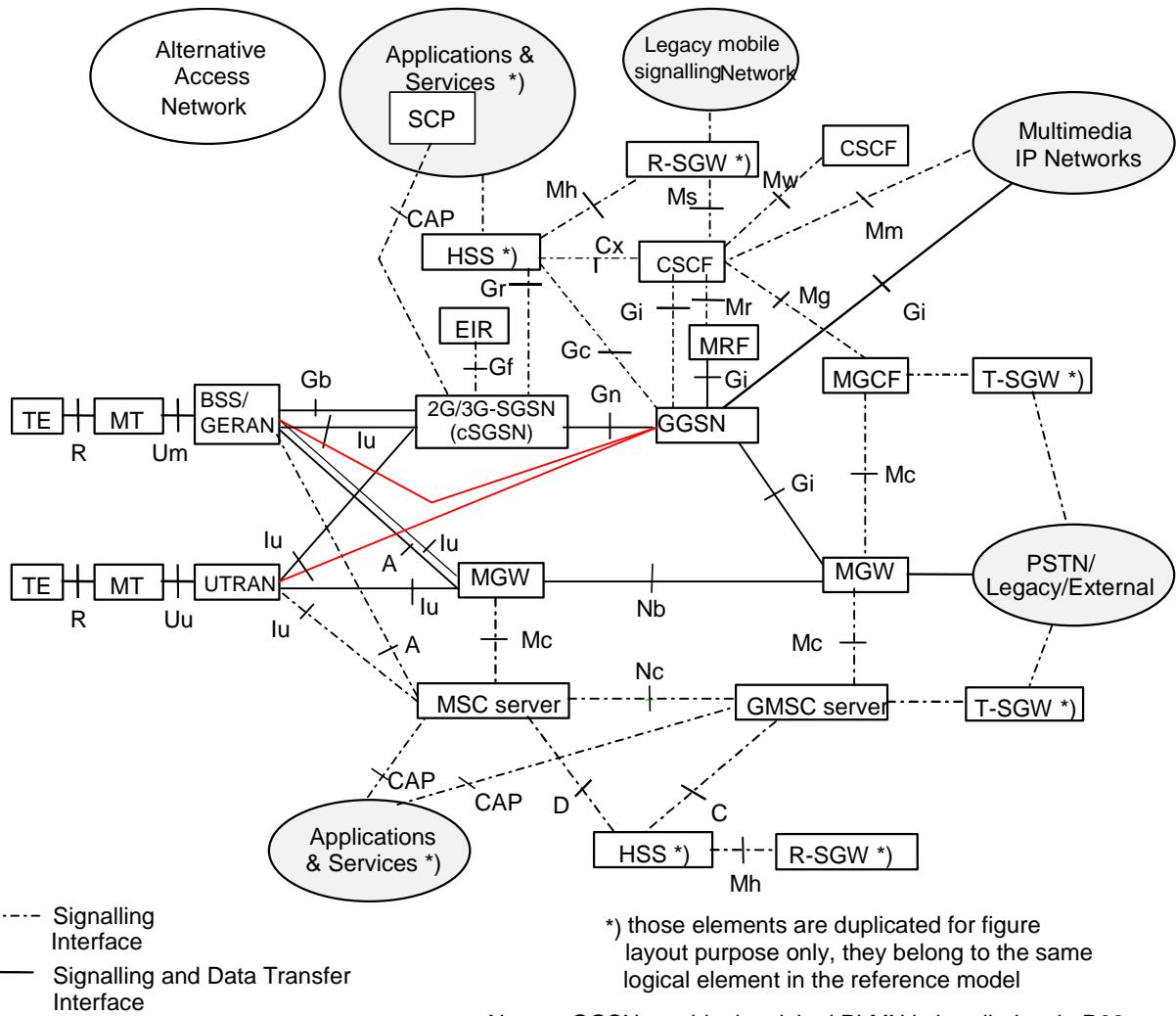
Figure 33: Evolved logical architecture for the One Tunnel Approach

7.2.1   Functional Nodes

Only functional nodes relevant for the One Tunnel Approach are described, i.e. which are changed compared with R99 or used differently.

7.2.1.1   2G-SGSN

This evolved architecture has no impact on the 2G-SGSN or its interfaces. A 2G-SGSN is necessary to support the Gb interface which does not support a separation of transport and control. The Gn interface of a 2G-SGSN supports both user and control data.

7.2.1.2   3G-SGSN / cSGSN

This evolved architecture has no impact on the 3G-SGSN and its interfaces and is compatible with it. A 3G-SGSN is necessary to support packet bearer services using GGSN external to the visited PLMN and packet bearer services using a R97-R99 GGSN.

The 3G-SGSN can be upgraded to become an SGSN without data transport functionality by adding new functionality and modifying its interface towards the xGGSN. In order to have a differentiation between a 3G-SGSN with and a 3G-SGSN without transport functionality in the following the SGSN performing only control functions is named cSGSN. To enable setup of a user plane tunnel from an RNC directly to a GGSN, it is necessary for the cSGSN to know that the GGSN in question is capable of handling the one tunnel scenarios.

The cSGSN controls the packet bearer services and handles all the signalling interfaces of an SGSN, including the GTP-C protocol on the Gn and Gp interfaces and the RANAP protocol on the Iu interface.

7.2.1.3 GGSN / xGGSN

The R99 GGSN can be upgraded to become a GGSN required for the one tunnel approach by adding new functionality and modifying its interface towards the cSGSN. In order to have a differentiation the following notion is introduced.

The notion of an (x)GGSN shall maintain a clear figure of the architecture. The (x)GGSN is a GGSN if 2G radio, a GGSN outside the visited network, a R97-R99 SGSN or a R97-R99 GGSN in the visited network shall be used. When a R99 GGSN is used two tunnels are established by the cSGSN, which then becomes an SGSN.

If one tunnel is established, the (x)GGSN is an xGGSN. Multiple GGSN and xGGSN can be in the same network. The xGGSN itself performs all functions of a GGSN and some additional functions of an SGSN.

7.2.2 Interfaces

Only interfaces relevant for the One Tunnel Approach are described, i.e. interfaces which are changed compared with 3GPP R99.

7.2.2.1 Gn (cSGSN – xGGSN)

This interface evolves to control the direct GTP tunnel between RAN and xGGSN and to deliver information for SGSN specific transport functions to the xGGSN (location information and prepaid budget).

The modifications compared with the R99 GTP version are:

- One Tunnel information field is introduced as optional information into the PDP context creation and the modification messages. By means of this IE the SGSN notifies the GGSN of the establishment of one tunnel. Inside this IE additional information can be included, e.g. information whether the TEID and user data transport address are allocated or not, CAMEL information (e.g. initial budget), charging information (e.g. whether location dependent charging is required), interception information (e.g. wether location dependent interception is required).

- The location report procedure is introduced (request and acknowledge).

- The charging report procedure is introduced for CAMEL prepaid (request and acknowledge).

- A procedure is required for requesting CAMEL prepaid volume data when time threshold elapses and at subscription change from CAMEL to CDR based charging. For this latter case, it is also required to signal that CAMEL based charging should be stopped.

- For some procedures the sequence of the R99 messages is changed or an additional update is introduced to concatenate the Iu and the Gn GTP tunnels to one tunnel.

Two aspects of the enhancement of the GTP has to be considered. The first one are the extensions of the GTP. As shown above it is necessary to extend some messages with optional information elements and some new procedures are needed.

The second aspect is how can an SGSN know whether a GGSN is upgraded for the one tunnel approach or not. Only the SGSN has to know whether a GGSN is enabled for the one tunnel approach or not. The GGSN is always ` ignalling via optional information elements described above whether one tunnel is established or not. The Ies are also used to command the GGSN to perform additional functions like CAMEL. After an SGSN change the GGSN is enabled or disabled for the one tunnel approach by means of the included or respectively not included Ies.

There are three possibilities to solve this problem; administration, a new GTP version and the use of optional information elements. In the following all alternatives should be discussed. Regarding the formats of the messages all alternatives are equal. The only difference is the mechanism to recognize the capabilities of the GGSNs.

Administration

By means of administration the SGSNs know which GGSNs are enabled for the one tunnel approach.

New GTP version

The introduction of a new GTP version is an automatic possibility for a SGSN to recognise whether a GGSN is an enhanced GGSN or not. By means of the version handling the SGSN knows in advance whether an one tunnel connection can be established with the concerned GGSN.

The disadvantage is the introduction of a new GTP version. The advantage is the easy automatic recognition of the capabilities of the GGSNs.

Introduction of optional Information Element

This alternative uses at least one additional information element. This IE is described above and is a Type-Length-Value (TLV) IE.

During a PDP context activation the SGSN adds the 'One Tunnel' IE in the Create PDP Context Request message. Due to this IE an updated GGSN knows that one tunnel shall be established and which functionalities are additionally required e.g. CAMEL. The updated GGSN acknowledges the request with a 'One Tunnel Response' IE in the Create PDP Context Response message. Due to the sent 'One Tunnel Response' IE the SGSN knows that the GGSN is updated and the one tunnel approach can be used.

In the case the GGSN is not updated, then the 'One Tunnel' IE is unknown for this GGSN. According to 3G TS 29.060 unknown optional Ies shall be ignored. Since the 'One Tunnel' IE is a TLV IE the GGSN skips this IE using its length value. This mechanism guarantees that the message is correctly interpreted except the 'One Tunnel' IE. A not updated GGSN answers as usual with a Create PDP Context Response message but without the acknowledgement of the one tunnel establishment. So due to the missing optional IE the SGSN knows that this GGSN is not updated.

This mechanism is also used during an inter SGSN change. But then the Update PDP Context Request and Update PDP Context Response are used.

The SGSN should store the capabilities of the GGSNs. Then the SGSN would know in advance which GGSN is updated.

Proposal

It is proposed to use the third alternative. This mechanism offers the best compatibility. Only through optional Ies and additional message flows the current GTP version is enabled for the One Tunnel approach.

[Note: The final decision is an N4 issue.]

Roaming to a home GGSN

If it is required to establish a PDP context towards a home GGSN then the SGSN has to establish two tunnels. During the APN and GGSN selection defined in 3G TS 23.060 the SGSN determines whether the GGSN is in the VPLMN or in the HPLMN.

7.2.3 User Plane

The protocol stack for the user plane is shown in Figure 34. The protocol stacks in the UE, in the 3G-RAN and the 3G-GGSN are the same as specified in the 3GPP R99 architecture. The user plane protocols specified for the SGSN are not needed in the One Tunnel Approach. Instead the IP transport network adapts different physical transport protocols below IP if necessary. It is the IP Transport Network also used to forward the packets between RAN entities at relocation or handover and provides the connectivity between the core network nodes. In case two tunnels are established, e.g. to use R99 GGSN, the R99 user plane as described in 23.060 applies.
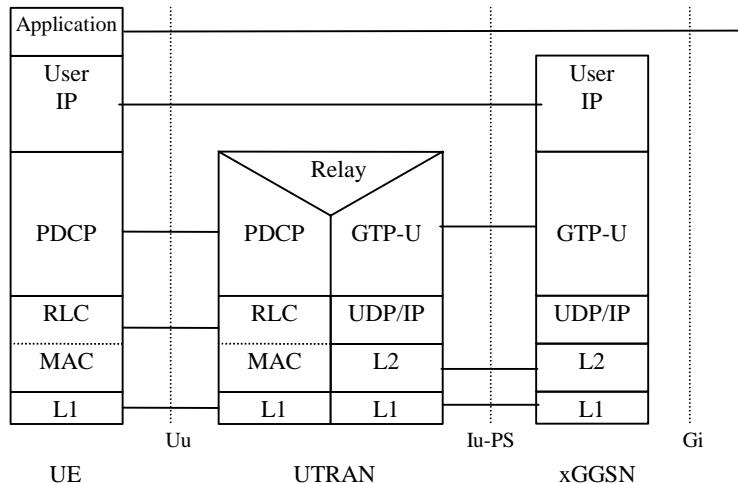
Figure 34: User plane protocol stack

7.3 Mobility Management

The procedures are for packet bearer services using a GGSN in the visited network with a 3G RAN, i.e. for the cSGSN / xGGSN architecture of the One Tunnel Approach. For all other bearer services or 2G RAN the R99 procedures and the SGSN / GGSN as specified in TS 23.060 apply. Modifications compared with 3GPP R99 are in italic.

7.3.1 Inter ISGSN Routeing Area Update

The Inter ISGSN Routeing Area Update procedure is illustrated in Figure 35. The difference compared with 3GPP R99 is in step 5) when the change is from a cSGSN or an SGSN to a cSGSN. In this case the Tunnel Endpoint Identifier delivered to the xGGSN indicates the reserved "not allocated" value for the traffic path as the Iu bearer is released and no tunnel endpoint is allocated at the RAN. At a change to an SGSN from SGSN or from cSGSN step 5) is handled as specified in 3GPP R99 (the SGSN TEID and IP address are sent to the xGGSN). The procedure described here is applicable for change between any combination of SGSN and cSGSN.
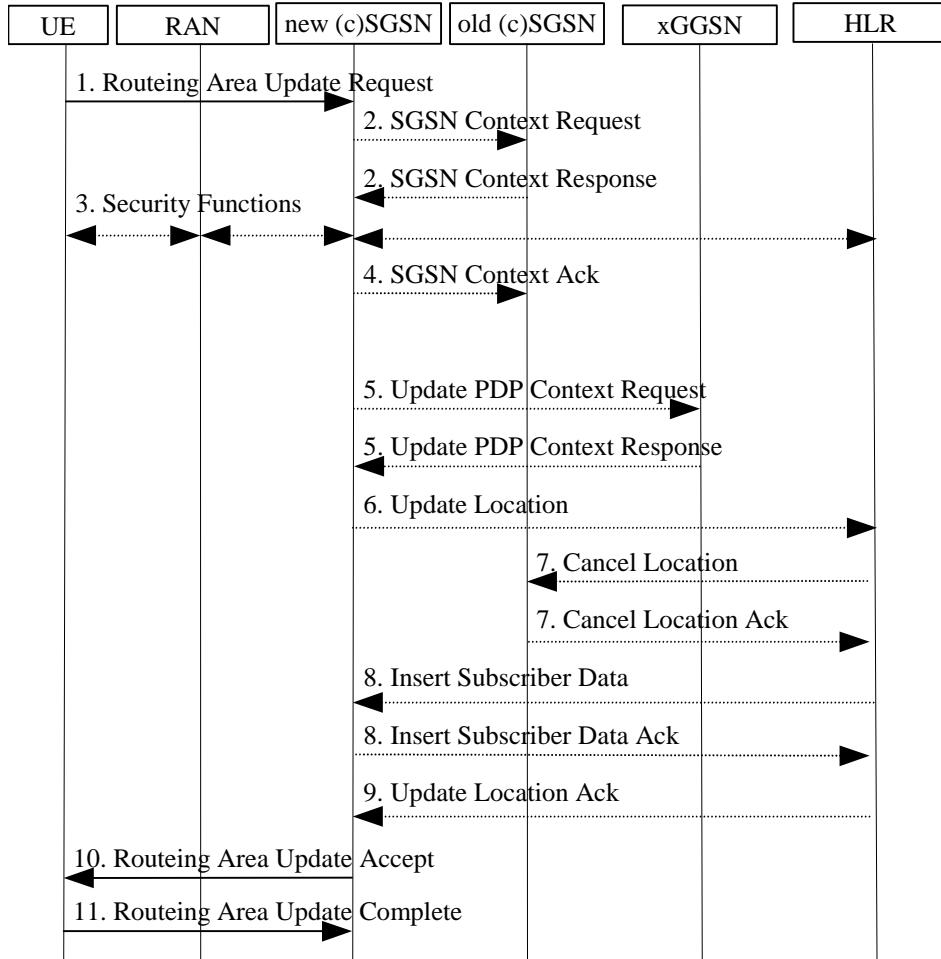
Figure 35: Inter ISGSN Routeing Area Update Procedure

1) The UE sends a Routeing Area Update Request message (P-TMSI, old RAI, old P-TMSI Signature, Update Type, follow on request) to the new ISGSN. Follow on request shall be set by UE if there is pending uplink traffic (signalling or user data). The ISGSN may use, as an implementation option, the follow on request indication to release or keep the Iu connection after the completion of the RA update procedure. The RAN adds the Routeing Area Identity including the RAC and LAC of the area where the UE is located before forwarding the message to the ISGSN.

2) If the RA update is an Inter-ISGSN Routeing area update and if the UE was in PMM-IDLE state, the new ISGSN sends SGSN Context Request message (old P-TMSI, old RAI, old P-TMSI Signature) to the old ISGSN to get the MM and PDP contexts for the UE. The old ISGSN validates the old P-TMSI Signature and responds with an appropriate error cause if it does not match the value stored in the old ISGSN. This should initiate the security functions in the new ISGSN. If the security functions authenticate the UE correctly, the new ISGSN shall send an SGSN Context Request (IMSI, old RAI, MS Validated) message to the old ISGSN. MS Validated indicates that the new ISGSN has authenticated the UE. If the old P-TMSI Signature was valid or if the new ISGSN indicates that it has authenticated the UE, the old ISGSN responds with SGSN Context Response (Cause, IUEI, MM Context, PDP contexts). If the UE is not known in the old ISGSN, the old ISGSN responds with an appropriate error cause. The old ISGSN starts a timer.

3) Security functions may be executed. These procedures are defined in subclause "Security Function" of TS 23.060. If the security functions do not authenticate the UE correctly, then the routeing area update shall be rejected, and the new ISGSN shall send a reject indication to the old ISGSN. The old ISGSN shall continue as if the ISGSN Context Request was never received.

4) If the RA update is an Inter-ISGSN Routeing area update, the new ISGSN sends an SGSN Context Acknowledge message to the old ISGSN. The old ISGSN marks in its context that the information in the (x)GGSNs and the HLR are invalid. This triggers the (x)GGSNs, and the HLR to be updated if the UE initiates a

routeing area update procedure back to the old ISGSN before completing the ongoing routeing area update procedure.

5) If the RA update is an Inter-ISGSN RA Update and if the UE was in PMM-IDLE state, the new ISGSN sends Update PDP Context Request (new SGSN Address, QoS Negotiated, Tunnel Endpoint Identifier) to the (x)GGSNs concerned. The (x)GGSNs update their PDP context fields and return an Update PDP Context Response (Tunnel Endpoint Identifier). *If the new ISGSN is a cSGSN the Tunnel Endpoint Identifier indicate the reserved "not allocated" value for the traffic path as the Iu bearer is released and no tunnel endpoint is allocated at the RAN. In addition the CAMEL characteristics with the prepaid budget are sent to the xGGSN if applicable. If the new ISGSN is an SGSN the Tunnel Endpoint Identifier allocated at the SGSN is indicated to the (x)GGSN.*

Note: If the RA update is an Inter-ISGSN routeing area update initiated by an UE in PMM-CONNECTED state, then the Update PDP Context Request message is sent as described in subclause "Serving RNS Relocation Procedures".

6) If the RA update is an Inter-ISGSN RA Update, the new ISGSN informs the HLR of the change of ISGSN by sending Update Location (SGSN Number, SGSN Address, IMSI) to the HLR.

7) If the RA update is an Inter-ISGSN RA Update, the HLR sends Cancel Location (IMSI, Cancellation Type) to the old ISGSN with Cancellation Type set to Update Procedure. If the timer described in step 2 is not running, then the old ISGSN removes the MM context. Otherwise, the contexts are removed only when the timer expires. It also ensures that the MM context is kept in the old ISGSN in case the UE initiates another inter ISGSN routeing area update before completing the ongoing routeing area update to the new ISGSN. The old ISGSN acknowledges with Cancel Location Ack (IMSI).

8) If the RA update is an Inter-ISGSN RA Update, the HLR sends Insert Subscriber Data (IMSI, subscription data) to the new ISGSN. The new ISGSN validates the UE's presence in the (new) RA. If due to regional subscription restrictions the UE is not allowed to be attached in the RA, the ISGSN rejects the Routeing Area Update Request with an appropriate cause, and may return an Insert Subscriber Data Ack (IMSI, SGSN Area Restricted) message to the HLR. If all checks are successful then the ISGSN constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

9) If the RA update is an Inter-ISGSN RA Update, the HLR acknowledges the Update Location by sending Update Location Ack (IMSI) to the new ISGSN.

10) The new ISGSN validates the UE's presence in the new RA. If due to roaming restrictions the UE is not allowed to be attached in the ISGSN, or if subscription checking fails, then the ISGSN rejects the routeing area update with an appropriate cause. If all checks are successful then the new ISGSN establishes MM context for the UE. The new ISGSN responds to the UE with Routeing Area Update Accept (P-TMSI, VLR TMSI, P-TMSI Signature).

11) The UE confirms the reallocation of the TMSIs by returning a Routeing Area Update Complete message to the ISGSN.

For an UE with GPRS-CSI defined, CAMEL interaction may be performed, see referenced procedures in 3G TS 23.078:

C1) CAMEL-GPRS-SGSN-Context-Acknowledge.

C2) CAMEL-GPRS-Routeing-Area-Update-Session.

C3) CAMEL-GPRS-Routeing-Area-Update-Context.

7.3.2 Location Report Procedure

This procedure is necessary in order to inform the xGGSN about the location of a subscriber. This is needed e.g. for location dependent interception or location dependent charging.
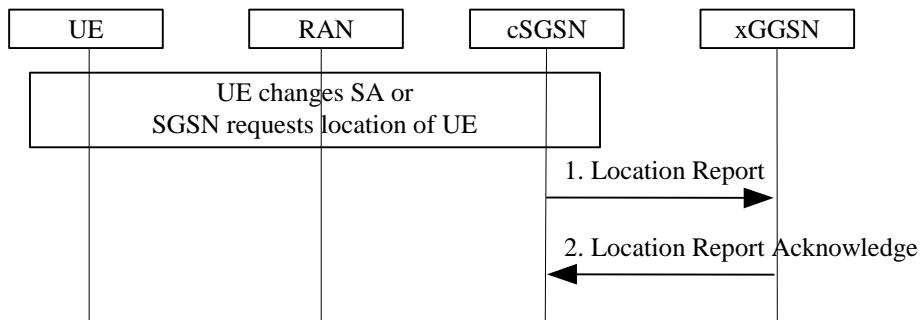
Figure 36: Location Report Procedure

1) The cSGSN sends a Location Report message to the xGGSN. This could contain the SAI or a geographical area as defined in 25.413.

2) The xGGSN acknowledges the reception of the message. Internally the xGGSN performs the location dependent functionality.

7.3.3 Serving SRNS Relocation Procedure

The Serving SRNS Relocation procedure is illustrated in figure 37. The sequence is valid for both intra cSGSN SRNS relocation and inter cSGSN SRNS relocation. The differences to 3GPP R99 are: in step 4) the RAN is provided with the user data TEID and user data Address of the xGGSN instead that of the SGSN and in step 11) the xGGSN gets the user data TEID and the user data signalling address of the RAN instead that of the SGSN.
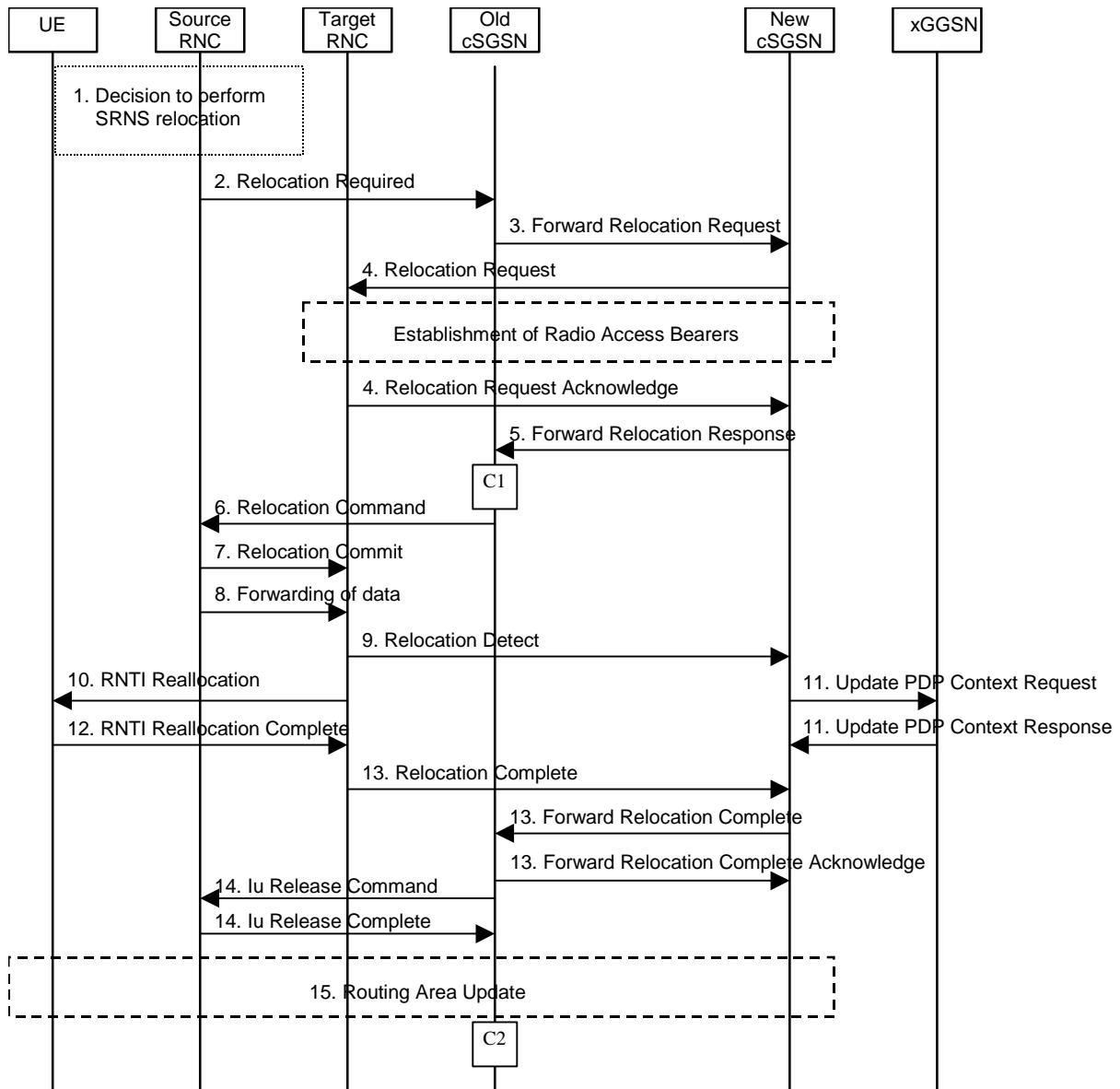
Figure 37: Serving SRNS Relocation Procedure

1) The source SRNC decides to perform/initiate an SRNS relocation.

2) The source SRNC initiates the relocation preparation procedure by sending a Relocation Required message (Relocation Type, Cause, Source ID, Target ID, Source RNC to target RNC transparent container) to the old cSGSN. The source SRNC shall set the Relocation Type to "UE not involved". The Source to Target RNC Transparent Container includes the necessary information for Relocation co-ordination, security functionality and RRC protocol context information (including UE Capabilities).

3) The old cSGSN determines from the Target ID if the SRNS Relocation is intra cSGSN SRNS relocation or inter cSGSN SRNS relocation. In case of inter cSGSN SRNS relocation the old cSGSN initiates the relocation resource allocation procedure by sending a Forward Relocation Request message (IMSI, Tunnel Endpoint Identifier Signalling, MM Context, PDP Context, Target Identification, UTRAN transparent container, RANAP Cause) to the new cSGSN. At the same time a timer is started on the MM and PDP contexts in the old cSGSN (see the Routeing Area Update procedure). The Forward Relocation Request message is applicable only in case of inter cSGSN SRNS relocation.

4) The new cSGSN sends a Relocation Request message (Permanent NAS UE Identity, Cause, CN Domain Indicator, Source RNC to target RNC transparent container, RABs to be setup) to the target RNC. For each RAB requested to be established, the RABs to be setup information elements shall contain information such as RAB ID, RAB parameters, Transport Layer Address, and Iu Transport Association. The RAB ID information element contains the NSAPI value, and the RAB parameters information element gives the QoS profile. The Transport

Layer Address is the *xGGSN* Address for user data, and the Iu Transport Association corresponds to Tunnel Endpoint Identifier Data *allocated by the xGGSN*. After all necessary resources for accepted RABs including the Iu user plane are successfully allocated, the target RNC shall send the Relocation Request Acknowledge message (RABs setup, RABs failed to setup) to the new cSGSN. The target RNC will for each RAB to be setup (defined by an IP Address and a Tunnel Endpoint Identifier) receive both forwarded downstream PDUs from the source SRNC as well as downstream PDUs from the *xGGSN*.

5) When the new cSGSN is ready for relocation of SRNS, the Forward Relocation Response message (Cause, RANAP Cause, and RAB Setup Information) is sent from new cSGSN to old cSGSN. This message indicates that the target RNC is ready to receive from source SRNC the downstream packets not yet acknowledged by the UE, i.e. the relocation resource allocation procedure is terminated successfully. RANAP Cause is information from the target RNC to be forwarded to the source RNC. The RAB Setup Information, one information element for each RAB, contain the RNC Tunnel Endpoint Identifier and RNC IP address for data forwarding from source SRNC to target RNC. If the target RNC or the new cSGSN failed to allocate resources the RAB Setup Information element contains only NSAPI indicating that the source RNC shall release the resources associated with the NSAPI. The Forward Relocation Response message is applicable only in case of inter cSGSN SRNS relocation.

6) The old cSGSN continues the relocation of SRNS by sending a Relocation Command message (RABs to be released, and RABs subject to data forwarding) to the source SRNC. The old cSGSN decides the RABs to be subject for data forwarding based on QoS, and those RABs shall be contained in RABs subject to data forwarding. For each RAB subject to data forwarding, the information element shall contain RAB ID, Transport Layer Address, and Iu Transport Association. The Transport Layer Address and Iu Transport Association is used for forwarding of DL N-PDU from source RNC to target RNC.

7) Upon reception of the Relocation Command message from the PS domain, the source RNC shall start the data-forwarding timer. When the relocation preparation procedure is terminated successfully and when the source SRNC is ready, the source SRNC shall trigger the execution of relocation of SRNS by sending a Relocation Commit message (SRNS Contexts) to the target RNC. The purpose of this procedure is to transfer SRNS contexts from the source RNC to the target RNC. SRNS contexts are sent for each concerned RAB and contain the sequence numbers of the GTP-PDUs next to be transmitted in the uplink and downlink directions and the next PDCP sequence numbers that would have been used to send and receive data from the UE. For connections using RLC unacknowledged mode PDCP sequence numbers is not used.

If PDCP does not support lossless relocation, the acknowledged mode SRNS relocation procedures shall be performed as in unacknowledged mode. Hence PDCP sequence numbers shall not be transferred from old RNC to target RNC.

8) After having sent the Relocation Commit message, source SRNC begins the forwarding of data for the RABs to be subject for data forwarding. The data forwarding at SRNS relocation shall be carried out through the Iu interface, meaning that the data exchanged between source SRNC and target RNC are duplicated in the source SRNC and routed at IP layer towards the target RNC.

9) The target RNC shall send a Relocation Detect message to the new cSGSN when the relocation execution trigger is received. For SRNS relocation type "UE not involved", the relocation execution trigger is the reception of the Relocation Commit message from the Iur interface. When the Relocation Detect message is sent, the target RNC shall start SRNC operation.

10) After having sent the Relocation Detect message, target SRNC responds to the UE by sending a RNTI Reallocation message. Both messages contain UE information elements and CN information elements. The UE information elements include among others new SRNC identity and S-RNTI. The CN information elements contain among others Location Area Identification and Routeing Area Identification. The procedure shall be co-ordinated in all Iu signalling connections existing for the UE.

The target SRNC resets and restarts the RLC connections, and exchanges the PDCP sequence numbers (PDCP-SNU, PDCP-SND) between the target SRNC and the UE. PDCP-SND is the PDCP sequence number for the next expected in-sequence downlink packet to be received in acknowledged mode in the UE per radio bearer, which requires lossless relocation. PDCP-SND confirms all mobile-terminated packets successfully transferred before the start of the relocation procedure. If PDCP-SND confirms reception of packets that were forwarded from the source SRNC, then these packets shall be discarded by the target SRNC. PDCP-SNU confirms all mobile originated packets successfully transferred before the start of the relocation procedure. If PDCP-SNU confirms reception of packets that were received in the source SRNC, then these packets shall be discarded by the UE.

11) Upon reception of the Relocation Detect message, the CN may switch the user plane from source RNC to target SRNC. If the SRNS Relocation is an inter cSGSN SRNS relocation, the new cSGSN sends Update PDP Context Request messages (new *signalling* SGSN Address, *signalling* SGSN Tunnel Endpoint Identifier, *RAN Address for user data, RAN TEID for user data,* QoS Negotiated) to the xGGSNs concerned. The xGGSNs update their PDP context fields and return an Update PDP Context Response (GGSN Tunnel Endpoint Identifier *separated for signalling and for user data*).

12) When the UE has reconfigured itself, it sends the RNTI Reallocation Complete message to the target SRNC. From now on the exchange of packets with the UE can start.

13) When the target SRNC receives the RNTI Reallocation Complete message, i.e. the new SRNC—ID + S-RNTI are successfully exchanged with the UE by the radio protocols, the target SRNC shall initiate the Relocation Complete procedure by sending the Relocation Complete message to the new cSGSN. The purpose of the Relocation Complete procedure is to indicate by the target SRNC the completion of the relocation of the SRNS to the CN. If the user plane has not been switched at Relocation Detect and upon reception of Relocation Complete, the CN shall switch the user plane from source RNC to target SRNC. If the SRNS Relocation is an inter cSGSN SRNS relocation, the new cSGSN shall signal to the old cSGSN the completion of the SRNS relocation procedure by sending a Forward Relocation Complete message.

14) Upon receiving the Relocation Complete message or if it is an inter cSGSN SRNS relocation; the Forward Relocation Complete message, the old cSGSN sends an Iu Release Command message to the source RNC. When the RNC data-forwarding timer has expired the source RNC responds with an Iu Release Complete.

15) After the UE has finished the RNTI reallocation procedure and if the new Routeing Area Identification is different from the old one, the UE initiates the Routeing Area Update procedure. Note that it is only a subset of the RA update procedure that is performed, since the UE is in PMM-CONNECTED mode.

For an MS with GPRS-CSI defined, CAMEL interaction may be performed, see referenced procedures in 3G TS 23.078:

C1) CAMEL-GPRS-SGSN-Context-Acknowledge.

C2) CAMEL-GPRS-Routeing-Area-Update.

7.3.4   Combined Hard Handover and SRNS Relocation Procedure

With the same modifications as for the SRNS Relocation Procedure above compared to 3GPP R99 this procedure relocates the direct GTP tunnel between RAN and xGGSN from one RNC to the other.

7.3.5   UMTS to GSM Change

In this case the procedure is the same as specified in 23.060 for the R99 UMTS to GSM change. The SRNS Data Forward Command delivers from cSGSN to the SRNC tunnel endpoints for the packets to be forwarded. These tunnels terminate in the cSGSN as in R99. The downlink data flow is then GGSN – SRNC – cSGSN – 2G-SGSN until the GGSN is updated.

7.3.6   GSM to UMTS SGSN Change

The intersystem change from GSM to UMTS takes place when a GPRS-attached UE changes from GSM radio access to UTRAN and the UTRAN node serving the UE is served by a different SGSN. In this case the RA changes. Therefore, the UE shall initiate a UMTS RA update procedure by establishing a RRC connection and initiating the RA update procedure. The RA update procedure is either combined RA / LA update or only RA update.

If the network operates in mode I, then an UE that is both PS-attached and CS-attached shall perform the Combined RA / LA Update procedures. This concerns only idle mode (see 3G TS 23.122), as no combined RA / LA updates are performed during a CS connection.

7.3.6.1 Intra SGSN Change

The difference compared with 3GPP R99 is, that an additional Update PDP Context in step 4) is needed. This message indicates to the xGGSN the reserved "not allocated" value for the traffic path as the Iu bearer is not yet allocated at the RAN. In step 12) the xGGSN tunnel endpoints are indicated to the RNC instead of the SGSN tunnel endpoints. Furthermore, for clarification in step 12) the parameters for RAB establishment are described as already specified in R99. Step 13) is additional compared to 3GPP R99 to update the xGGSN with the GTP tunnel IP address and the TEID received from the RAN when the Service Request is initiated which is the same as for the standalone Service Request procedure.
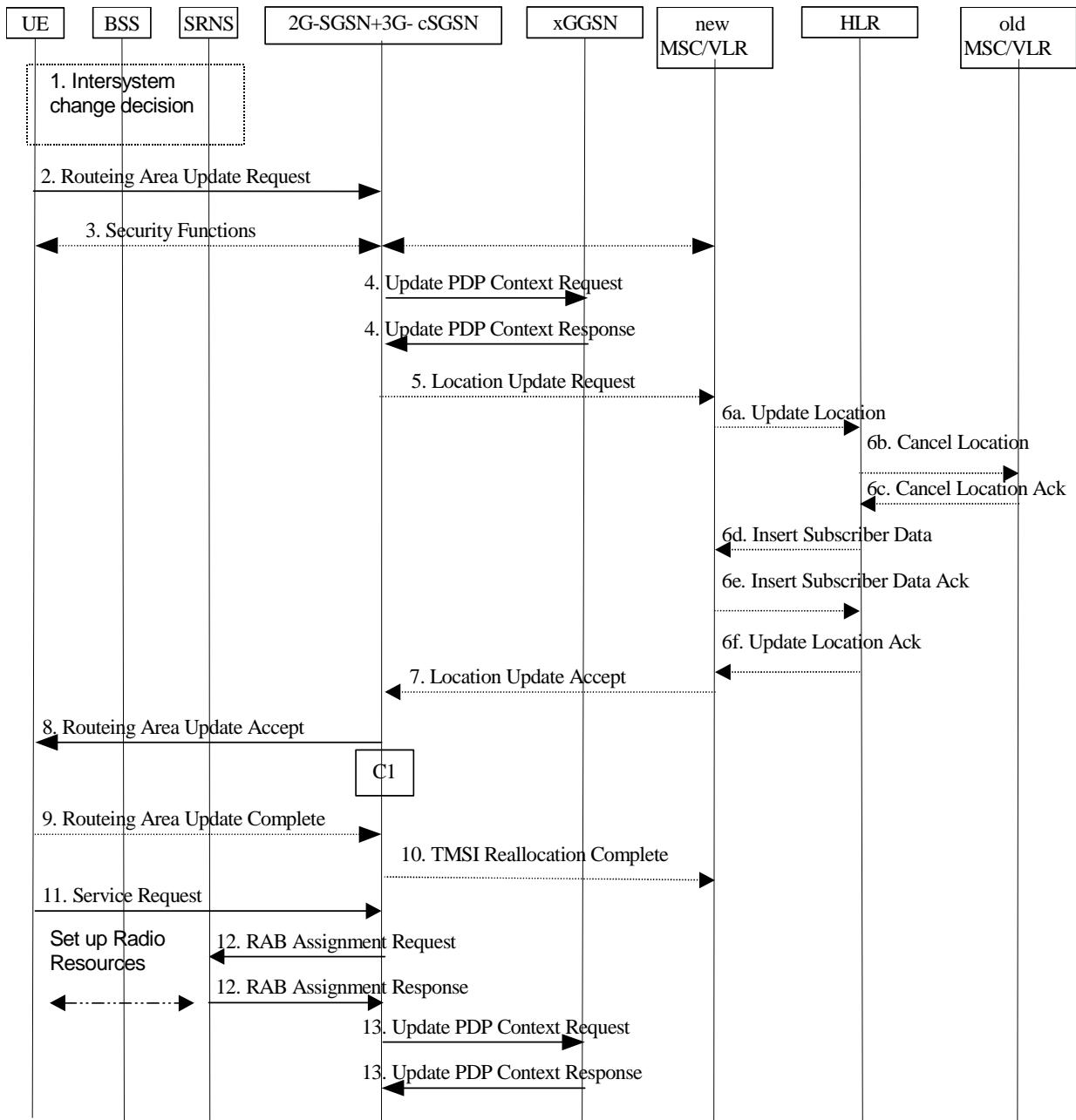
Figure 38: GSM to UMTS Inter SGSN Change

1-3) as described in 23.060

4) The cSGSN sends an Update PDP Context Request (new SGSN Address, TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and return an Update PDP Context Response (TEID) message. *The Tunnel Endpoint Identifier delivered to the xGGSN indicates the reserved "not allocated" value for the traffic path as the RAB is not yet established and no tunnel endpoint is allocated at the RAN.*

5-12) as described in 23.060

13) If the UE has send the Service Request and when the cSGSN received the IP address(es) and the TEID(s) from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, RAN TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and xGGSN is established.

7.3.6.2 Inter SGSN Change

The difference compared with 3GPP R99 is, that the Update PDP Context in step 8) indicates to the xGGSN the reserved "not allocated" value for the traffic path as the Iu bearer is not yet allocated at the RAN. In step 20) the xGGSN tunnel endpoints are indicated to the RNC instead of the SGSN tunnel endpoints. Furthermore, for clarification in step 20) the parameters for RAB establishment are described as already specified in R99. Step 21) is additional compared to 3GPP R99 to update the xGGSN with the GTP tunnel IP address and the TEID received from the RAN when the Service Request is initiated which is the same as for the standalone Service Request procedure.
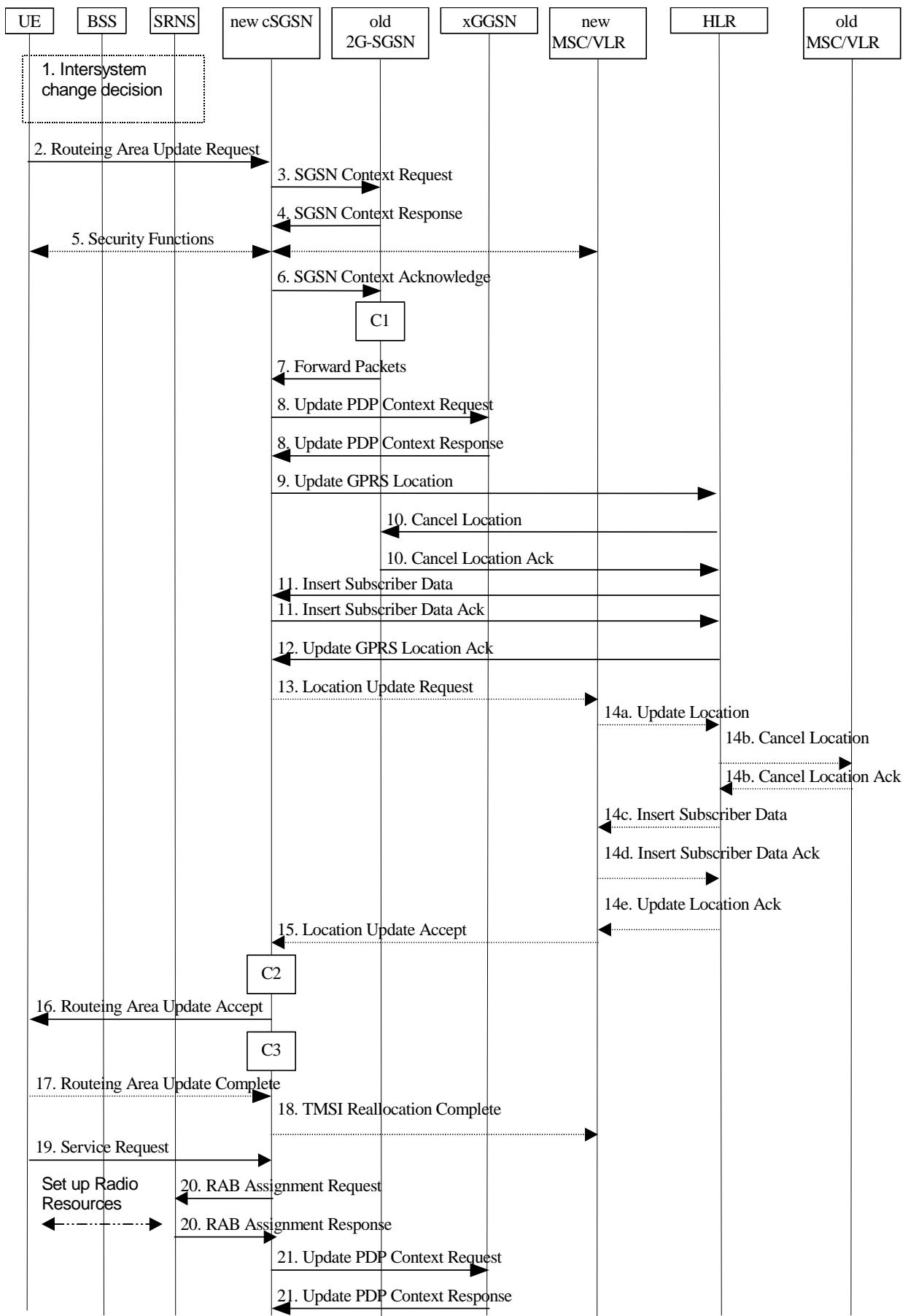
Figure 39: GSM to UMTS Inter SGSN Change

1) The UE or BSS or UTRAN decides to perform an intersystem change, which makes the UE switch to a new cell that supports UMTS radio technology, and stops transmission to the network.

2) The UE sends a Routeing Area Update Request (P-TMSI, old RAI, old P-TMSI Signature, Update Type, CM) message to the new cSGSN. Update Type shall indicate RA update or combined RA / LA update, or, if the UE wants to perform an IMSI attach, combined RA / LA update with IMSI attach requested. The SRNC shall add the Routeing Area Identity including the RAC and LAC of the area where the UE is located before forwarding the message to the cSGSN. This RA identity corresponds to the RAI in the MM system information sent by the SRNC to the UE.

3) The new cSGSN uses the old RAI received from the UE to derive the old 2G-SGSN address, and sends an SGSN Context Request (old RAI, old P-TMSI, New SGSN Address) message to the 2G-SGSN to get the MM and PDP contexts for the MS. The old 2G-SGSN starts a timer and stops the transmission of N-PDUs to the UE.

4) The old 2G-SGSN responds with an SGSN Context Response (MM Context, PDP Contexts) message. Each PDP Context includes the GTP sequence number for the next downlink N-PDU to be sent to the UE and the GTP sequence number for the next uplink N-PDU to be tunnelled to the GGSN. Each PDP Context also includes the SNDCP Send N-PDU Number for the next downlink N-PDU to be sent in acknowledged mode to the UE and the SNDCP Receive N-PDU Number for the next uplink N-PDU to be received in acknowledged mode from the UE. The new cSGSN shall use the GTP sequence numbers for in-sequence delivery over the Iu interface.

5) Security functions may be executed.

6) The new cSGSN sends an SGSN Context Acknowledge message to the old 2G-SGSN. This informs the old 2G-SGSN that the new 3G-SGSN is ready to receive data packets belonging to the activated PDP contexts. The old SGSN marks in its context that the MSC/VLR association and the information in the GGSNs and the HLR are invalid. This triggers the MSC/VLR, the GGSNs, and the HLR to be updated if the UE initiates a routeing area update procedure back to the old SGSN before completing the ongoing routeing area update procedure.

7) The old 2G-SGSN duplicates the buffered N-PDUs and starts tunnelling them to the new cSGSN. Additional N-PDUs received from the GGSN before the timer described in step 3 expires are also duplicated and tunnelled to the new cSGSN. No N-PDUs shall be forwarded to the new cSGSN after expiry of the timer described in step 3.

8) The new cSGSN sends an Update PDP Context Request (new SGSN Address, TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and return an Update PDP Context Response (TEID) message. *The Tunnel Endpoint Identifier delivered to the xGGSN indicates the reserved "not allocated" value for the traffic path as the RAB is not yet established and no tunnel endpoint is allocated at the RAN.*

9) The new cSGSN informs the HLR of the change of SGSN by sending an Update GPRS Location (SGSN Number, SGSN Address, IMSI) message to the HLR.

10) The HLR sends a Cancel Location (IMSI, Cancellation Type) message to the old 2G-SGSN. The old 2G-SGSN removes the MM and PDP contexts if the timer described in step 3 is not running. If the timer is running the MM and PDP contexts are removed when the timer expires. The old 2G-SGSN acknowledges with a Cancel Location Ack (IMSI) message.

11) The HLR sends an Insert Subscriber Data (IMSI, GPRS Subscription Data) message to the new cSGSN. The cSGSN constructs an MM context for the UE and returns an Insert Subscriber Data Ack (IMSI) message to the HLR.

12) The HLR acknowledges the Update GPRS Location by returning an Update GPRS Location Ack (IMSI) message to the new cSGSN.

13) If the association has to be established, if Update Type indicates combined RA / LA update with IMSI attach requested, or if the LA changed with the routeing area update, then the new SGSN sends a Location Update Request (new LAI, IMSI, SGSN Number, Location Update Type) to the VLR. Location Update Type shall indicate IMSI attach if Update Type in step 1 indicated combined RA / LA update with IMSI attach requested. Otherwise, Location Update Type shall indicate normal location update. The VLR number is translated from the RAI by the cSGSN. The cSGSN starts the location update procedure towards the new MSC/VLR upon receipt of the first Insert Subscriber Data message from the HLR in step 12). The VLR creates or updates the association with the cSGSN by storing SGSN Number.

14) If the subscriber data in the VLR is marked as not confirmed by the HLR, the new VLR informs the HLR. The HLR cancels the old VLR and inserts subscriber data in the new VLR (this signalling is not modified from existing GSM signalling and is included here for illustrative purposes):

   a) The new VLR sends an Update Location (new VLR) to the HLR.

   b) The HLR cancels the data in the old VLR by sending Cancel Location (IMSI) to the old VLR.

   c) The old VLR acknowledges with Cancel Location Ack (IMSI).

   d) The HLR sends Insert Subscriber Data (IMSI, GSM subscriber data) to the new VLR.

   e) The new VLR acknowledges with Insert Subscriber Data Ack (IMSI).

   f) The HLR responds with Update Location Ack (IMSI) to the new VLR.

15) The new VLR allocates a new TMSI and responds with Location Update Accept (VLR TMSI) to the cSGSN. VLR TMSI is optional if the VLR has not changed.

16) The new cSGSN validate the MS's presence in the new RA. If due to roaming restrictions the UE is not allowed to be attached in the cSGSN, or if subscription checking fails, then the new cSGSN rejects the routeing area update with an appropriate cause. If all checks are successful then the new cSGSN constructs MM and PDP contexts for the MS. The new cSGSN responds to the UE with a Routeing Area Update Accept (P-TMSI, P-TMSI signature) message.

17) The UE acknowledges the new P-TMSI by returning a Routeing Area Update Complete message to the cSGSN.

18) The new cSGSN sends TMSI Reallocation Complete message to the new VLR if the VLR TMSI is confirmed by the MS.

19) If the UE was in GPRS MM state READY it sends a Service Request (P-TMSI, RAI, CKSN, Service Type) message to the cSGSN. Service Type specifies the requested service. Service Type shall indicate one of the following: Data or Signalling.

20) If the UE has send the Service Request the new cSGSN requests the SRNS to establish a radio access bearer by sending a RAB Assignment Request (RAB ID(s), QoS Profile(s), GTP-SNDs, GTP-SNUs, PDCP-SNUs) message to the SRNS. For each RAB requested to be established, the RABs to be setup information elements shall contain information such as RAB ID, RAB parameters, Transport Layer Address, and Iu Transport Association. The RAB ID information element contains the NSAPI value, and the RAB parameters information element gives the QoS profile. The Transport Layer Address is the *xGGSN* Address for user data, and the Iu Transport Association corresponds to Tunnel Endpoint Identifier Data *allocated by the xGGSN*. The PDCP sequence numbers shall be derived from the N-PDU sequence numbers stored in the PDP contexts. The SRNS sends a Radio Bearer Setup Request (PDCP-SNUs) message to the UE. The UE responds with a Radio Bearer Setup Complete (PDCP-SNDs) message. The SRNS responds with a RAB Assignment Response message. The cSGSN sends N-PDUs tunnelled from the old SGSN to the SRNS. The SRNS shall discard all N-PDUs tunnelled from the SGSN with N-PDU sequence numbers older than the PDCP-SNDs received from the MS. Other N-PDUs shall be transmitted to the MS. The UE shall discard all N-PDUs with sequence numbers older than the PDCP-SNUs received from the SRNS. Other N-PDUs shall be transmitted to the SRNS.

21) If the UE has send the Service Request and when the cSGSN received the IP address(es) and the TEID(s) from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, RAN TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and xGGSN is established.

   NOTE: The NSAPI value is carried in the RAB ID IE.

For an UE with GPRS-CSI defined, CAMEL interaction may be performed, see referenced procedures in 3G TS 23.078:

   C1)   CAMEL-GPRS-SGSN-Context-Acknowledge.

   C2)   CAMEL-GPRS-Routeing-Area-Update-Session.

   C3)   CAMEL-GPRS-Routeing-Area-Update-Context.

7.4 Session Management

The procedures are for packet bearer using a GGSN in the visited network with a 3G RAN, i.e. for the cSGSN / xGGSN architecture of the One Tunnel Approach. For all other bearer services or 2G RAN the R99 procedures and the SGSN / GGSN as specified in TS 23.060 apply. Modifications compared with 3GPP R99 are in italic.

7.4.1 PDP Context Activation Procedure

For better comparison with the 3GPP R99 PDP context activation procedure all PDP parameter checks and descriptions are included in the description, although the procedure applies only for bearer services using a GGSN in the visited network. The difference compared with 3GPP R99 is the creation of the PDP context on the xGGSN before the RAB setup. And this PDP context creation on the xGGSN in step 2) indicates the reserved "not allocated" value for the traffic path as the Iu bearer is not yet allocated at the RAN. Furthermore, CAMEL information is indicated if applicable for that context. Step 5) is additional compared to 3GPP R99 to update the xGGSN with the GTP tunnel IP address and the TEID received from the RAN.
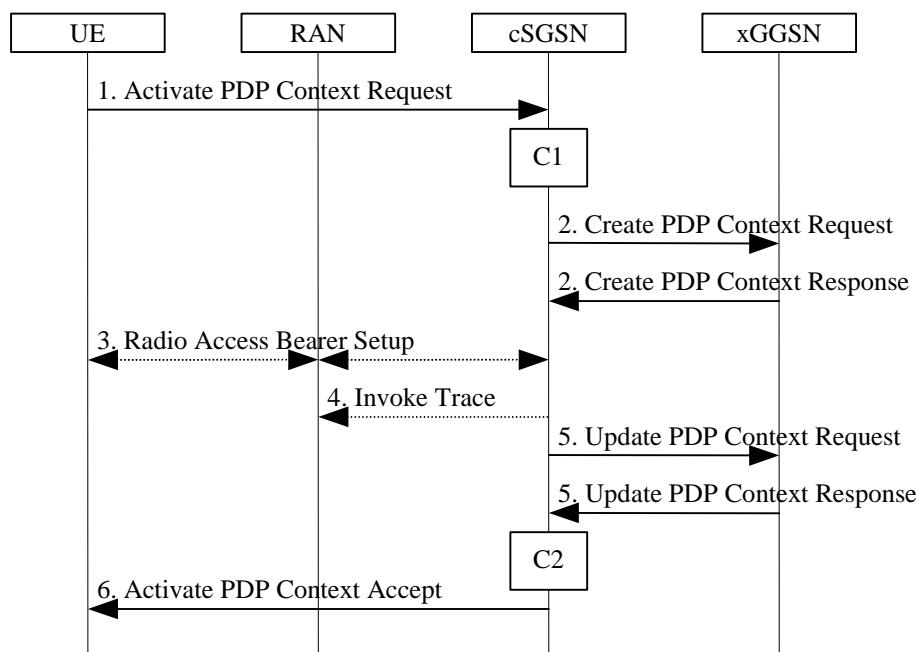
Figure 40: PDP Context Activation Procedure

1) The UE sends an Activate PDP Context Request (NSAPI, TI, PDP Type, PDP Address, Access Point Name, QoS Requested, PDP Configuration Options) message to the cSGSN. The UE shall use PDP Address to indicate whether it requires the use of a static PDP address or whether it requires the use of a dynamic PDP address. The UE shall leave PDP Address empty to request a dynamic PDP address. The UE may use Access Point Name to select a reference point to a certain external network and/or to select a service. Access Point Name is a logical name referring to the external packet data network and/or to a service that the subscriber wishes to connect to. QoS Requested indicates the desired QoS profile. PDP Configuration Options may be used to request optional PDP parameters from the xGGSN (see GSM 09.60). PDP Configuration Options is sent transparently through the cSGSN.

2) The cSGSN validates the Activate PDP Context Request using PDP Type (optional), PDP Address (optional), and Access Point Name (optional) provided by the UE and the PDP context subscription records. The validation criteria, the APN selection criteria, and the mapping from APN to a xGGSN are described in annex A.

If no xGGSN address can be derived or if the cSGSN has determined that the Activate PDP Context Request is not valid according to the rules described in annex A, then the cSGSN rejects the PDP context activation request.

If a xGGSN address can be derived, the cSGSN creates a TEID for the requested PDP context. If the UE requests a dynamic address, then the cSGSN lets a xGGSN allocate the dynamic address. The cSGSN may restrict the requested QoS attributes given its capabilities, the current load, and the subscribed QoS profile.

The cSGSN sends a Create PDP Context Request (PDP Type, PDP Address, Access Point Name, QoS Negotiated, TEID, NSAPI, UEISDN, Selection Mode, Charging Characteristics, Trace Reference, Trace Type, Trigger Id, OMC Identity, PDP Configuration Options) message to the affected xGGSN. Access Point Name shall be the APN Network Identifier of the APN selected according to the procedure described in annex A. PDP Address shall be empty if a dynamic address is requested. The xGGSN may use Access Point Name to find an external network and optionally to activate a service for this APN. Selection Mode indicates whether a subscribed APN was selected, or whether a non-subscribed APN sent by UE or a non-subscribed APN chosen by cSGSN was selected. Selection Mode is set according to annex A. The xGGSN may use Selection Mode when deciding whether to accept or reject the PDP context activation. For example, if an APN requires subscription, then the xGGSN is configured to accept only the PDP context activation that requests a subscribed APN as indicated by the cSGSN with Selection Mode. Charging Characteristics indicates which kind of charging the PDP context is liable for. The cSGSN shall derive Charging Characteristics from Subscribed Charging Characteristics and/or PDP context Charging Characteristics if received from the HLR as follows: if a "PDP context Charging Characteristics" is present for this PDP context, it shall be sent; otherwise if a "Subscribed Charging Characteristics" is present for this subscriber it shall be sent. If neither "PDP context Charging Characteristics" nor a "Subscribed Charging Characteristics" is present, the cSGSN may choose a default Charging Characteristics which would be sent to the xGGSN, and used there as well. The Charging Characteristics sent to the xGGSN shall also include an indication whether it was retrieved from subscription data received from the HLR or is a default profile determined by the cSGSN.The cSGSN shall include Trace Reference, Trace Type, Trigger Id, and OMC Identity if xGGSN trace is activated. The cSGSN shall copy Trace Reference, Trace Type, and OMC Identity from the trace information received from the HLR or OMC. *The Tunnel Endpoint Identifier indicate the reserved "not allocated" value for the traffic path as the Iu bearer is not yet allocated at the RAN. If CAMEL prepaid is applicable the CAMEL characteristics and a prepaid budget are sent to the xGGSN.*

The xGGSN creates a new entry in its PDP context table and generates a Charging Id. The new entry allows the xGGSN to route PDP PDUs between the cSGSN and the external PDP network, and to start charging. When the Charging Characteristics sent by the cSGSN have been determined by the cSGSN (not retrieved from HLR subscription data), the xGGSN may choose to ignore this. The charging characteristics on the GPRS subscription and individually subscribed APNs are specified in 3G TS 32.015. The xGGSN then returns a Create PDP Context Response (TEID, PDP Address, PDP Configuration Options, QoS Negotiated, Charging Id, Cause) message to the cSGSN. PDP Address is included if the xGGSN allocated a PDP address. If the xGGSN has been configured by the operator to use External PDN Address Allocation for the requested APN, then PDP Address shall be set to 0.0.0.0, indicating that the PDP address shall be negotiated by the UE with the external PDN after completion of the PDP Context Activation procedure. The xGGSN shall relay, modify and monitor these negotiations as long as the PDP context is in ACTIVE state, and use the xGGSN-Initiated PDP Context Modification procedure to transfer the currently-used PDP address to the cSGSN and the UE. PDP Configuration Options contain optional PDP parameters that the xGGSN may transfer to the UE. These optional PDP parameters may be requested by the UE in the Activate PDP Context Request message, or may be sent unsolicited by the xGGSN. PDP Configuration Options is sent transparently through the cSGSN. The Create PDP Context messages are sent over the backbone network.

If QoS Negotiated received from the cSGSN is incompatible with the PDP context being activated, then the xGGSN rejects the Create PDP Context Request message. The compatible QoS profiles are configured by the xGGSN operator.

3) RAB setup is done by the RAB Assignment procedure, see subclause "RAB Assignment Procedure" in TS 23.060.

4) If BSS trace is activated, then the cSGSN shall send an Invoke Trace (Trace Reference, Trace Type, Trigger Id, OMC Identity) message to the BSS or RAN. Trace Reference, and Trace Type are copied from the trace information received from the HLR or OMC.

5) Having received the IP address and the TEID from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, TEID, QoS Negotiated) message to the xGGSN. The xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and the xGGSN is established.

6) The cSGSN inserts the NSAPI along with the xGGSN address in its PDP context. If the UE has requested a dynamic address, the PDP address received from the xGGSN is inserted in the PDP context. The cSGSN selects Radio Priority and Packet Flow Id based on QoS Negotiated, and returns an Activate PDP Context Accept (PDP Type, PDP Address, TI, QoS Negotiated, Radio Priority, Packet Flow Id, PDP Configuration Options) message to the UE. The cSGSN is now able to route PDP PDUs between the xGGSN and the UE, and to start charging.

For an UE with GPRS-CSI defined, CAMEL interaction may be performed, see referenced procedures in 3G TS 23.078:

C1) CAMEL-GPRS-Activate-PDP-Context.

C2) CAMEL-GPRS-SGSN-Create-PDP-Context.

7.4.2 Secondary PDP Context Activation Procedure

The Secondary PDP Context Activation procedure may only be initiated after a PDP context is already activated for the same PDP address and APN. The procedure is illustrated in figure 41. The difference compared with 3GPP R99 is the creation of the PDP context on the xGGSN before the RAB setup. And this PDP context creation on the xGGSN in step 2) indicates the reserved "not allocated" value for the traffic path as the Iu bearer is not yet allocated at the RAN. Step 4) is additional compared to 3GPP R99 to update the xGGSN with the GTP tunnel IP address and the TEID received from the RAN.
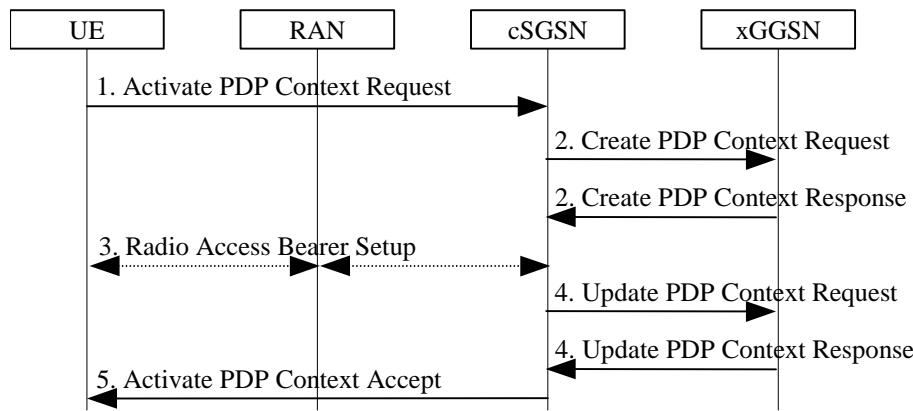
Figure 41: Secondary PDP Context Activation Procedure for UMTS

1) The UE sends an Activate Secondary PDP Context Request (Linked TI, NSAPI, TI, QoS Requested, TFT) message to the cSGSN. Linked TI indicates the TI value assigned to any one of the already activated PDP contexts for this PDP address and APN. QoS Requested indicates the desired QoS profile. TFT is sent transparently through the cSGSN to the xGGSN to enable packet classification for downlink data transfer. TI and NSAPI contain values not used by any other activated PDP context.

2) The cSGSN validates the Activate Secondary PDP Context Request using the TI indicated by Linked TI. The same xGGSN address is used by the cSGSN as for the already-activated PDP context(s) for that TI and PDP address.

   The cSGSN and xGGSN may restrict and negotiate the requested QoS as specified in subclause "PDP Context Activation Procedure". The cSGSN sends a Create PDP Context Request (QoS Negotiated, TEID, NSAPI, Primary NSAPI, TFT) message to the affected xGGSN. Primary NSAPI indicates the NSAPI value assigned to any one of the already activated PDP contexts for this PDP address and APN. TFT is included only if received in the Activate Secondary PDP Context Request message. The xGGSN uses the same external network as used by the already-activated PDP context(s) for that PDP address, generates a new entry in its PDP context table, and stores the TFT. The new entry allows the xGGSN to route PDP PDUs via different GTP tunnels between the cSGSN and the external PDP network. The xGGSN returns a Create PDP Context Response (TEID, QoS Negotiated, Cause) message to the cSGSN. *The Tunnel Endpoint Identifier ` ignallin to the xGGSN indicates the reserved "not allocated" value for the traffic path as the RAB is not yet established and no tunnel endpoint is allocated at the RAN.*

3) RAB setup is done by the RAB Assignment procedure.

4) *Having received the IP address and the TEID from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, TEID, QoS Negotiated) message to the xGGSN. The xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and the xGGSN is established.*

5) The cSGSN selects Radio Priority and Packet Flow Id based on QoS Negotiated, and returns an Activate Secondary PDP Context Accept (TI, QoS Negotiated, Radio Priority, Packet Flow Id) message to the UE. The cSGSN is now able to route PDP PDUs between the xGGSN and the UE via different GTP tunnels and possibly different LLC links.

7.4.3 Iu Release Procedure

The RAN initiates an Iu release procedure to release all RABs of an UE and the Iu connection. The Iu Release procedure is illustrated in figure 42. The difference compared with 3GPP R99 is the additional step 2) informing the xGGSN, that the transport tunnel endpoint at the RAN is no more allocated.
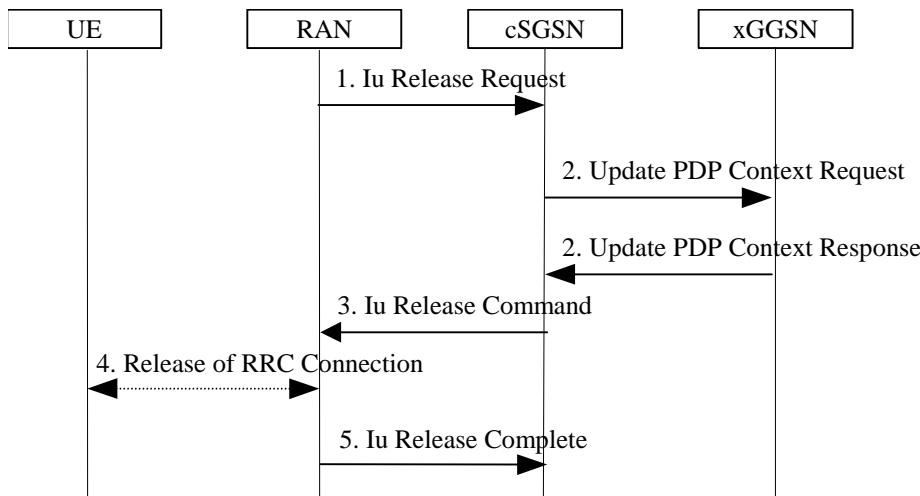
Figure 42: Iu Release Procedure

1) RAN sends an Iu Release Request (Cause) message to the cSGSN.

2) *The cSGSN sends an Update PDP Context Request (RAN Address, TEID, QoS Negotiated) message to each xGGSN concerned. The Tunnel Endpoint Identifier indicate the reserved "not allocated" value for the traffic path as the Iu bearer is not allocated at the RAN. Each xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel endpoint at the xGGSN remains allocated. The cSGSN holds the information about the xGGSN tunnel endpoints.*

3) The cSGSN sends an Iu Release Command (Cause) message to RAN.

4) The RRC connection is released if still existing.

5) RAN confirms the Iu release by sending an Iu Release Complete (For each released RAB: RAB ID, GTP SND, GTP SNU) message to cSGSN. GTP SND and GTP SNU enable the cSGSN to restore the values in case the PDP context is maintained and the RAB is re-established at a later stage.

7.4.4 Service Request Initiated by UE Procedure

The UE in PMM-IDLE state sends the Service Request message to the cSGSN in order to establish the PS signalling connection for the upper layer signalling or for the resource reservation for active PDP context(s). This procedure is also used by an UE in PMM-CONNECTED state to request the resource reservation for the active PDP contexts. The differences compared with 3GPP R99 are the delivery of the xGGSN tunnel parameter instead of the SGSN parameters in step 3) to the RAN and the additional step 4) informing the xGGSN, that the transport tunnel endpoint at the RAN is re-established.
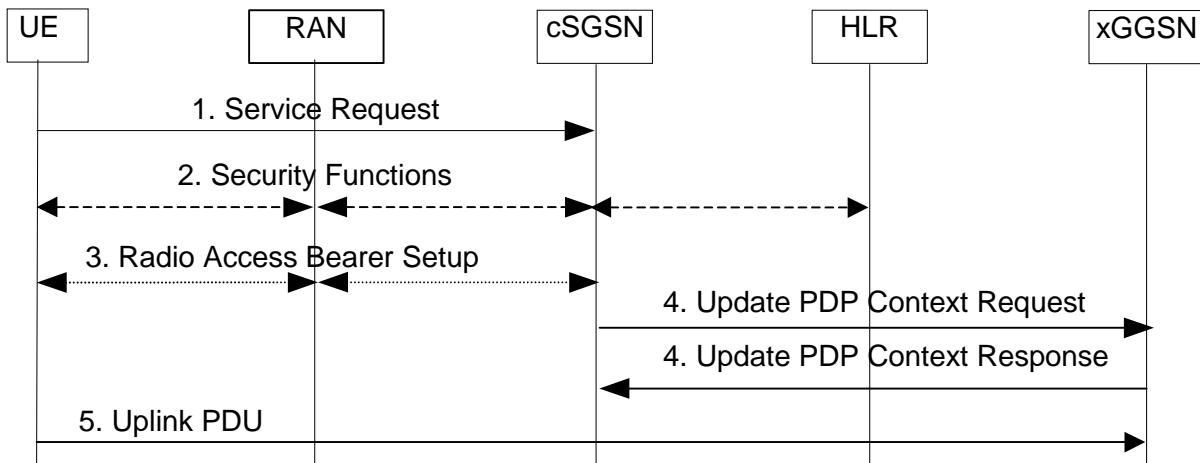
Figure 43: Service Request Initiated by UE Procedure

1) The UE sends a Service Request (P-TMSI, RAI, CKSN, Service Type) message to the cSGSN. Service Type specifies the requested service. Service Type shall indicate one of the following: Data or Signalling. At this point, the cSGSN may perform the authentication procedure.

   If Service Type indicates Data then a signalling connection is established between the UE and the cSGSN, and resources for active PDP context(s) are allocated, i.e., RAB establishment for the activated PDP context(s).

   If Service Type indicates Signalling then the signalling connection is established between the UE and the cSGSN for sending upper-layer signalling messages, e.g., Activate PDP Context Request. The resources for active PDP context(s) are not allocated.

2) The cSGSN shall perform the security functions if the service request was initiated by an UE in PMM-IDLE state.

3) In case Service Type indicates Data, the cSGSN sends a Radio Access Bearer Assignment Request (NSAPIRAB ID(s), *xGGSN* TEID(s), QoS Profile(s), *xGGSN IP Address(es)*) message to re-establish radio access bearer for every activated PDP context. *The xGGSN tunnel endpoint parameters are held by the cSGSN also when the Iu is released.*

4) *Having received the IP address(es) and the TEID(s) from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, RAN TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and xGGSN is re-established.*

5) The UE sends the uplink packet.

7.4.5   Service Request Initiated by Network Procedure

When the xGGSN receives a downlink packet for a PDP context with a not allocated GTP tunnel (UE in PMM-IDLE state), the xGGSN notifies the cSGSN. This initiates a paging request to trigger the Service Request procedure in the UE. Compared with 3GPP R99 the GTP tunnel at the xGGSN is not established after Iu release. Therefore, the reception of a downlink PDU at the xGGSN triggers the PDU Notification Procedure to request the re-establishment of the RAB(s). Furthermore, after RAB establishment the xGGSN has to be updated before being able to transfer downlink PDUs. These are the additional steps 2) and 7) compared with 3GPP R99.
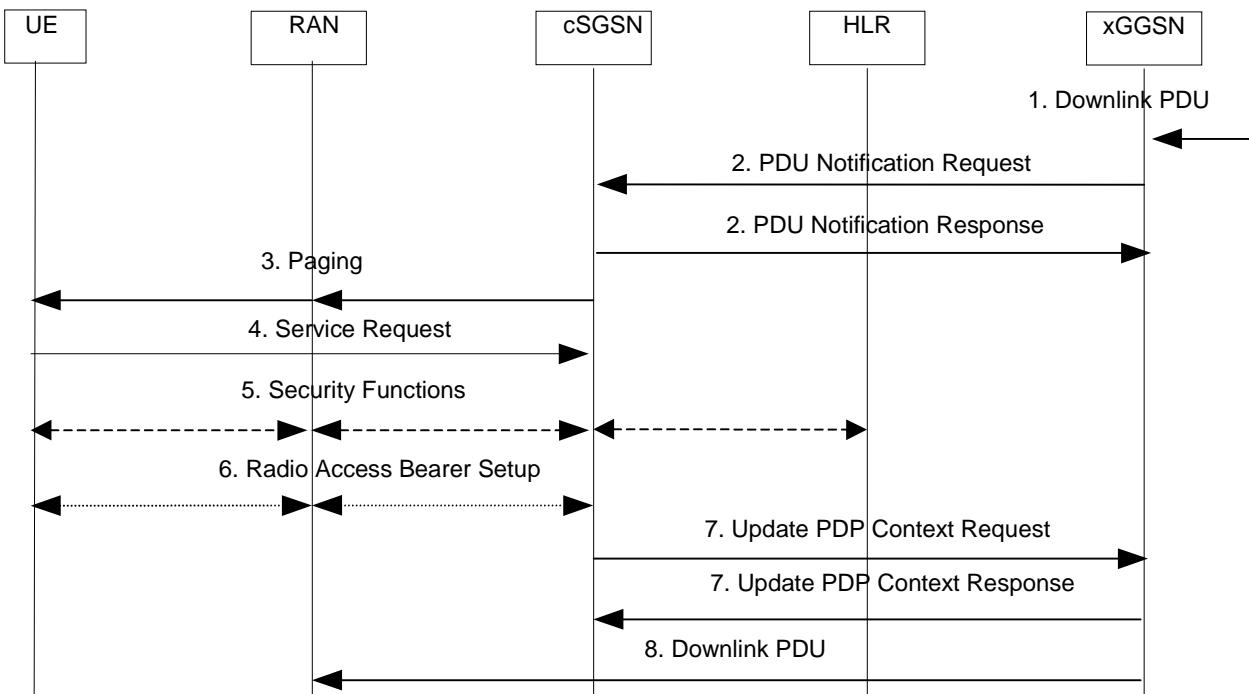
Figure 44: Service Request Initiated by Network Procedure

1) The xGGSN receives a downlink PDP PDU for an UE in PMM-IDLE state.

2) *The xGGSN sends a PDU Notification Request message to the cSGSN related to the PDP context. The cSGSN returns a PDU Notification Response (Cause) message to the xGGSN in order to acknowledge that it shall request the UE to re-activate the PDP context(s).*

3) The cSGSN sends a Paging message to the RNC. The RNC pages the UE by sending a Paging message to the UE. See subclause "PS Paging Initiated by 3G-SGSN without RRC Connection for CS" in TS 23.060 for details.

4) The UE sends a Service Request (P-TMSI, RAI, CKSN, Service Type) message to the cSGSN. Service Type specifies Paging Response. The Service Request is carried over the radio in an RRC Direct Transfer message and over the Iu interface in the RANAP Initial UE message. At this point, the cSGSN may perform the authentication procedure. The cSGSN knows whether the downlink packet requires RAB establishment (e.g., downlink PDU) or not (e.g., Request PDP Context Activation or MT SMS).

5) The cSGSN shall perform the security mode procedure.

6) If resources for the PDP contexts are to be re-established, the cSGSN sends a Radio Access Bearer Assignment Request (RAB ID(s), *xGGSN* TEID(s), QoS Profile(s), *xGGSN* IP Address(es)) message to the RNC. The RNC sends a Radio Bearer Setup (RAB ID(s)) to the UE. The UE responds by returning a Radio Bearer Setup Complete message to the RNC. The RNC sends a Radio Access Bearer Assignment Response (RAB ID(s), TEID(s), RNC IP Address(es)) message to the cSGSN in order to indicate that GTP tunnels are established on the Iu interface and radio access bearers are established between the RNC and the UE. If the RNC returns a Radio Access Bearer Assignment Response message with a cause indicating that the requested QoS profile(s) can not be provided, e.g., "Requested Maximum Bit Rate not Available", then the cSGSN may send a new Radio Access Bearer Assignment Request message with different QoS profile(s). The number of re-attempts, if any, as well as how the new QoS profile(s) values are determined is implementation dependent.

7) *Having received the IP address(es) and the TEID(s) from the RAN the cSGSN sends an Update PDP Context Request (RAN Address, RAN TEID, QoS Negotiated) message to each xGGSN concerned. Each xGGSN updates its PDP context fields and returns an Update PDP Context Response (TEID) message. The tunnel between RAN and the xGGSN is re-established.*

8) The xGGSN sends the downlink packet.

7.5 Charging

There are three different types of charging information which are collected by the SGSN and/or the GGSN: Mobility Management information, SMS information and PDP context information. In the One Tunnel Approach the cSGSN doesn't collect the data volume for charging purposes. The charging functionality for Mobility Management information and for SMS remain unchanged on cSGSN. Only the xGGSN collects data volume information. It follows that data volume information is included only in the G-CDRs (GGSN-CDR). The S-CDRs (SGSN-CDR) doesn't contain any data volume information despite the unsuccessfully transmitted DL data volume reported by the RNC which is sent in separated S-CDRs by the cSGSN as specified in 3GPP R99.

If it is necessary to establish two tunnels, then the cSGSN performs also data volume charging functionality.

In order to enable location dependent charging the cSGSN forwards location information sent by the RNC to the xGGSN. The Location Report procedure (see above) shall be used. The xGGSN includes this information into the G-CDRs. The expected signalling traffic with location information does not increase the overall signalling considerably as otherwise this would impact the Iu signalling too.

7.6 CAMEL Considerations

In the One Tunnel Approach the data traffic passes only the xGGSN. Therefore volume dependent CAMEL functionality is performed by the xGGSN. All other CAMEL functionality remains in the cSGSN.

In the following, two aspects are described where the xGGSN is involved. The first one is the subscription change during established PDP context and second one is CAMEL prepaid.

7.6.1 Subscription Change during Established PDP Context

If due to subscription change, the SCP needs to get control on PDP contexts that were established using the One Tunnel approach, then the cSGSN activates all required functionality when the subscription change is signalled by the HLR. If CAMEL prepaid applies the cSGSN sends an Update PDP Context to the xGGSN including the CAMEL information and the prepaid budget which starts the prepaid functionality on the xGGSN.

7.6.2 CAMEL Prepaid

In the One Tunnel Approach the data traffic passes only the xGGSN. Therefore volume dependent CAMEL prepaid is performed by the xGGSN. The cSGSN sends by means of the Create PDP Context Request message the prepaid budget for the required context to the xGGSN. Also during an inter cSGSN change the prepaid budget will be transmitted to the xGGSN inside the Update PDP Context Request message.

If it is necessary to establish two tunnels, then the cSGSN performs also CAMEL prepaid functionality.

A dedicated procedure is introduced for requesting new budget or giving back unused budget. Between cSGSN and SCP the Apply Charging Report GPRS procedure is used as specified in R99. The following figure describes the procedure.
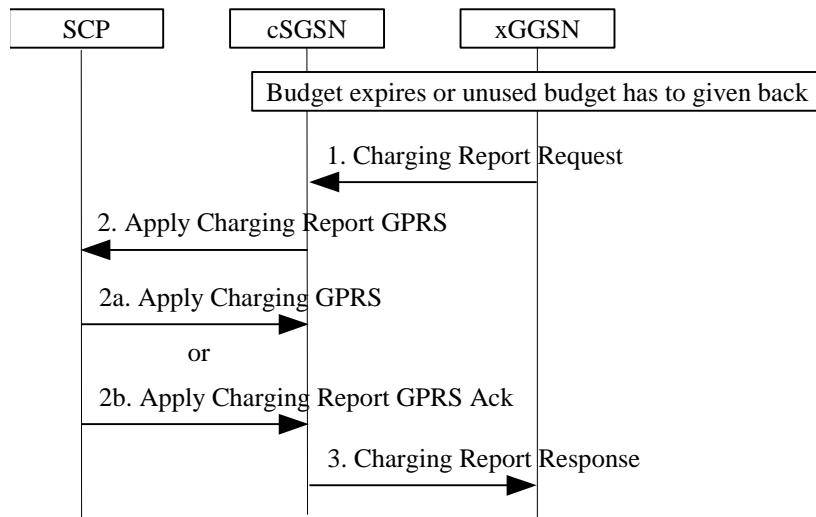
Figure 45: CAMEL prepaid reporting procedure

1) The xGGSN detects that the budget given by the SCP expires or budget has to given back. The xGGSN creates a Charging Report Request message and send it to the cSGSN.

2) The cSGSN forwards this message to the SCP. The SCP evaluates the request and answers with new budget (2a) or acknowledges returned budget (2b).

3) The cSGSN forwards the response of the SCP to the xGGSN.

7.7 Lawful Interception

3G TS 33.107 describes the architecture and functional requirements for interception for a 3rd generation mobile communication system. The specification applies to both SGSN and GGSN. There is only one difference interception at the GGSN is a national option which means in fact a GGSN is enabled for interception if an manufacturer does not implement two different GGSNs.

The One Tunnel Approach requires that interception in the xGGSN is mandatory because the data traffic passes only the xGGSN. So only the xGGSN will deliver the Content of Communication. The Interception Related Information will be sent as currently defined by cSGSN and xGGSN.

If it is necessary to establish two tunnels, then the cSGSN provides the functionality of delivery of the Content of Communication.

In order to enable Location Dependent Interception the cSGSN forwards location information sent by the RNC to the xGGSN. The Location Report procedure (see above) shall be used.

7.8 QoS Considerations

The removal of one GPRS specific node from the data path by the One Tunnel Approach improves the packet bearer QoS by reducing the packet transfer delay.

If two tunnels are established then the SGSN has to perform the following functions:

- IP/UDP termination

- GTP termination,

- look up for the corresponding PDP context,

- charging, possibly CAMEL,

- possibly interception,

- queueing and handling for QoS,

- GTP encapsulation,

- UDP/IP handling.

This has to be done for each packet. Implementations may perform charging, interception and CAMEL functionality somehow in parallel. All transport stack related functions have to be performed sequential. The overall delay is reduced by the delay induced by these functions.

Compared to the R99 approach the one tunnel approach the GGSN has to perform additionally only the CAMEL prepaid functionality. For charging purposes, a R99 GGSN counts transferred octets, which can be utilised for CAMEL prepaid. Interception is already a national option. As stated above such functions may be performed in parallel to the transport functionality. Therefore, with regard to the removal of SGSN functionality no additional transport functionality is introduced into the GGSN and therefore also no additional delay. Potential delay caused by processing capacity required for CAMEL or interception depends strongly on the implementation and can therefore not be estimated here.

All together the overall delay is at least reduced by the time needed to perform all transport stack functionality in the SGSN. The reduction is strongly dependent on the implementation and therefore cannot be estimated here.

7.9   Security

7.10   O&M

7.11   RAN Considerations (e.g. GERAN)

The One Tunnel Approach is applicable for any RAN with separated transport and control at the interface to the core network, i.e. for UTRAN and the Iu enabled part of the GERAN. The One Tunnel Approach has no impact on the RAN.

7.12   Abnormal Cases

7.13   Compatibility

7.14   Benefits and Drawbacks

The benefits and drawbacks are compared to the R'99 architecture, unless otherwise specified.

Benefits:

- Removes the SGSN from the user data path when this is possible (NB, it is expected to apply for most of the cases). The delay that the packets experience in the UMTS network is then decreased by bypassing the SGSN and by using optimal IP routing between the RNC and the GGSN.

- No SGSN capacity upgrades needed when traffic per user increases, dependent on the proportion of the PDP contexts activated with one user plane tunnel (NB, it is expected to apply for most of the cases).

- Charging dependent on PLMN internal or external traffic possible for CAMEL prepaid

- Can be achieved by software upgrade alone

Drawbacks:

- Not always applicable, i.e. not in case of 2G radio and when GGSN is not in the visited PLMN and also not in case of interworking with R97-R99 SGSNs and GGSNs

- The national option of legal interception on GGSN is mandatory in this approach

- Some additional control plane functionality embedded in the SGSN and GGSN, and this means increased standardisation and implementation (the changes are due to CAMEL prepaid, location information and in case of the GGSN the network initiated service request, and the SGSN and GGSN also need updates to support the other procedures listed under the 'Increased signalling' bullet).

- More vendor interoperability testing for RNC to GGSN interface is required.

- Increases signalling (location information, prepaid budget, CAMEL volume collection, PDP context activation, PDP context modification, Iu Release, Service Request, intersystem change, suspend and resume)

- Enhancements to GTP-C are needed

- As the GGSN has a direct interface with the SRNC, at intra cSGSN SRNS relocation, the GGSN is impacted (need to be given the new RNC address), which is not the case of the current architecture. The additional GGSN update traffic depends on the degree of user mobility and on the RNC size (if RNC area equal to SGSN area the update traffic does not change)

- The cSGSN node still has to contain the whole R99 SGSN functionality, including transport, to support the traffic cases that require two user plane tunnels and in addition the new functionality to handle the one tunnel case. This increases the complexity of the node compared to a R99 SGSN.

- Increases the time needed for signalling for some CAMEL based services, because there are more entities in the signalling path (i.e. xGGSN – cSGSN– SCP).

- Intersystem changes reduce the R99 advantages of co-locating 2G and 3G SGSNs.

7.15 Open Issues

- The actual reduction in delay by bypassing the SGSN in the transport plane is strongly dependent on implementation and can therefore not be exactly estimated here.

8 Summary

8.1 Selection Criteria

This subsection contains an unordered list of selection criteria which will be used as a guideline when the feasibility study makes its recommendation.

The selection criterion is divided into two parts. The first refers to specific aims of the Feasibility Study and is included to give a clear indication of the advantages expected from a migration from the R99 architecture. The second part consists of compatibility criteria, which are included to ensure that the selected alternative remains compatible with both present services and features that are required to be supported for future releases.

8.1.1 Aims

- Available in a timely manner (e.g., R4/R5). However, the interactions with a split of call control and user planes, also in UTRAN, need to be taken into consideration to allow comprehensive operator reasoning behind the viability of the split functionality

- The chosen approach should make efficient use of the network resources

- Can be implemented with minimum changes to other network entities

- Can evolve towards further control / transport (e.g. to support split GGSN)

- Allow the procurement of control entities and bearer entities from different vendors

- Reference points carrying signalling messages (e.g., Mp) shall not reduce the capabilities for the bearer entities to provide the equivalent QoS as present in the combined SGSN

- Efficient support, in terms of QoS, of future users of the packet bearers, e.g. the IP multimedia subsystem

8.1.2 Compatibility criteria

- Can be introduced into an existing network in a phased manner, i.e. can co-exist and inter-operate with non-split elements of the same type.

- Applicable for both pre-pay and subscription subscribers

- Applicable for both roaming and non-roaming subscribers

- Should not preclude the use of Mobile IP, both v4 and v6, in the future.

- Selected alternative will result in stability for the network architecture, thus minimizing standards churn.

- Can support all related regulatory functions, i.e. Lawful Interception.

8.2 Assignment of Functions to the Logical Architecture

The following table provides an overview of the functions performed by the different nodes of each alternative. SGSN and GGSN refer to R99 nodes and also to the case where it is not possible to establish one tunnel in alternative 2.

NOTE 1: For alternative 2, the SGSN and cSGSN functions on one hand, and the GGSN and xGGSN functions on the other hand, must be implemented by the same physical node in order to support the cases where one tunnel is not applicable. However in most cases it should be possible to establish one tunnel.

NOTE 2: In case intra SGSN intersystem change needs to be supported, the 2G-SGSN and the SGSN server must be implemented in the same physical node. However in most cases intra SGSN intersystem change should not be required.

Table 2: Mapping of Functions to Logical Architecture

Function	SGSN	cSGSN	SGSN-Server	PS-MGW	GGSN	xGGSN
Network Control:						
Authentication and Authorisation	X	X	X			
Admission Control	X	X	X	X	X	X
Session Management	X	X	X	X	X	X
PS-MGW Management			X	X		
PS-MGW Control			X	X		
Charging Event Collection	X	X	X		X	X
Charging Volume Data reporting				X		
Charging Volume Data Counting	X			X	X	X
Charging Volume Data Collection	X		X		X	X
CDR generation	X	X	X		X	X
RANAP fair charging reporting	X	X	X			
Location info reporting for charging		X				X
Location info reporting for LI		X	X			
Mobility Event Collection	X	X	X			
Legal Interception Content of Communication	X			X	O	X
Legal Interception Related Information	X	X	X		O	X
Forward CAMEL info to xGGSN or PS-MGW		X	X			
CAMEL Prepaid	X	X		X		X
SMS handling	X	X	X			

Packet Routeing & Transfer:						
Relay	X			X	X	X
Routeing	X			X	X	X
Address Translation and Mapping	X			X	X	X
Encapsulation	X			X	X	X
Tunnelling	X			X	X	X
Per Packet QoS Management	X			X	X	X
Mobility Management:	X	X	X		X	X

8.2.1 High-Level Functions Description

8.2.1.1 Network Control Functions

Authentication and Authorisation Function: This function performs the identification and authentication of the service requester, and the validation of the service request type to ensure that the user is authorised to use the particular network services. The authentication function is performed in association with the Mobility Management functions.

Admission Control Function: The purpose of admission control is to calculate which network resources are required to provide the quality of service (QoS) requested, determine if those resources are available, and then reserve those resources. Admission control is performed in association with the Radio Resource Management functions in order to estimate the radio resource requirements within each cell.

Charging Data Collection Function: This function collects data necessary to support subscription and/or traffic fees.

Forward location info: This function relays information delivered by RANAP to the xGGSN or to the PS-MGW to enable location dependent charging or interception.

Mobility Event Collection: This function collects all CAMEL events and forwards this information to the SCP.

Legal Interception Content of Communication: This function forwards the intercepted traffic to the LEA.

Legal Interception Related Information: This function forwards the user mobility events to the LEA.

Forward CAMEL info to xGGSN or PS-MGW: This function delivers prepaid budget to the function monitoring the traffic.

CAMEL Prepaid: This function monitors the traffic and consumes the budget according to the traffic, prevents further traffic when no more budget is available and returns not consumed budget at release of the session.

SMS handling: This function relays SMS between RAN and SMS-GMSC transferred via RANAP or MAP, respectively.

8.2.1.2 Packet Routeing and Transfer Functions

Relay Function: The relay function is the means by which a node forwards data received from one node to the next node in the route.

Routeing Function: The routeing function determines the network node to which a message should be forwarded and the underlying service(s) used to reach that GPRS Support Node (GSN), using the destination address of the message. The routeing function selects the transmission path for the "next hop" in the route.

Data transmission between GSNs may occur across external data networks that provide their own internal routeing functions, for example X.25 [34], Frame Relay or ATM networks.

Address Translation and Mapping Function: Address translation is the conversion of one address to another address of a different type. Address translation may be used to convert an external network protocol address into an internal network address that can be used for routeing packets within and between the PLMN(s).

Address mapping is used to map a network address to another network address of the same type for the routeing and relaying of messages within and between the PLMN(s), for example to forward packets from one network node to another.

Encapsulation Function: Encapsulation is the addition of address and control information to a data unit for routeing packets within and between the PLMN(s). Decapsulation is the removal of the addressing and control information from a packet to reveal the original data unit.

Encapsulation and decapsulation are performed between the support nodes of the packet domain PLMN(s), and between the serving support node and the UE.

Tunnelling Function: Tunnelling is the transfer of encapsulated data units within and between the PLMN(s) from the point of encapsulation to the point of decapsulation. A tunnel is a two-way point-to-point path. Only the tunnel endpoints are identified.

Per Packet QoS Management: It includes all packet processing to maintain the QoS especially the transfer delay and packet loss ratio within the limits negotiated for each PDP context.

8.2.1.3 Mobility Management Functions

The mobility management functions are used to keep track of the current location of an MS within the PLMN or within another PLMN.

8.3 Comparison of the Overall Functionality

The table below addresses the cases where the respective evolved architectures are applicable.

> NOTE 1: The split SGSN approach is not applicable when 2G radio is used.

> NOTE 2: The one tunnel approach is not applicable when 2G radio is used, at inter PLMN scenarios, and when R97-R99 SGSN and/or GGSN is used.

Table 3: Comparison of functionality between the two alternatives

	SGSN server – PS-MGW	One Tunnel
Mobility Management	Existing protocols not impacted. New protocol procedures required are confined to Mp interface.	Existing procedures and protocol (GTP) are impacted. New signalling on Gn interface is required.
Session Management	Existing protocols not impacted. New protocol procedures required are confined to Mp interface. PS-MGW participates in QoS negotiation.	Existing procedures and protocol (GTP) are impacted. New signalling on Gn interface is required.
Packet Routing and Transfer	On PS-MGW and on GGSN	On xGGSN
PS-MGW Control	New standard interface and related node control and management	---
Charging	On PS-MGW (only counters and cause), on SGSN server and on GGSN	On xGGSN, cSGSN (only events)
Network control load	SGSN server load is higher than R99 SGSN because of additional standard interface	CSGSN and xGGSN load is higher than R99 because of additional GTP signalling
Network traffic capacity	PS-MGW and GGSN capacity to be upgraded with growing user traffic. By having an m:n relationship between servers and PS-MGWs, an increase of the ability to better utilize the total network capacity is achieved, as servers can set up new PDP contexts on a different MGW when resources are scarce on one MGW. As a deployment option, this principle can even be used to share some MGW resources between CS and PS domain. These resources are lower layer protocols and hardware resources (e.g. interface cards), and parts related to the Mp interface, if H.248 is selected.	Only xGGSN capacity to be upgraded with growing user traffic
CAMEL	Events by SGSN server, prepaid budget via SGSN server to PS-MGW	Events by cSGSN, prepaid budget via cSGSN to xGGSN
Interception	Events by SGSN server, data by PS-MGW and as national option GGSN	Events by cSGSN or xGGSN, data by xGGSN
Location Info	For control on SGSN server as in R99, change indicated to PS-MGW for LI	For control on cSGSN as in R99, change indicated to xGGSN for LI and for charging
Network Management	SGSN server, PS-MGW, GGSN. New Mp links have to be managed	cSGSN, xGGSN
Packet Bearer QoS	As in R99	One PS domain specific hop removed – improved delay figures by bypassing the SGSN
Migration to the approach	SGSN gets new interface which has to be managed, no more traffic functions in the SGSN server; new entity PS-MGW and new protocol introduced. Existing protocols remain unchanged.	SGSN and GGSN get some control extensions in addition to the R99 functions; extensions to GTP
Recovery, Redundancy, Failure concepts	As in R99 and additionally between SGSN server and PS-MGW	As in R99

9 Work Plan

SA2#13	May 22-26, 2000	Proposal for a new Work Item.
CN/SA2 workshop	June 14-15, 2000	Discussion of Work Item responsibilities.
SA#8	June 26-28, 2000	Work Item and distribution of responsibilities approved.
Drafting session	August 22-24	Discussion and selection of alternative architectures to be studied. Start work on each alternative.
SA2#14	September 4-8, 2000	Work on the selected architectures.
SA#9	September 25-28, 2000	
Drafting session	October 17-19	Detailed work on the selected architectures.
SA2#15	November 13-17, 2000	Detailed work on the selected architectures. Approval by SA2 to present the TR for information to SA.
SA#10	December 11-14, 2000	Presentation of the TR to SA for information.
SA2#16	January 22-26, 2000	Finalise TR. Select the solution to be presented for approval.
SA#11	March 19 – 22, 2001	Presentation of the TR to SA for approval.

Annex A (informative): Combined SGSN and GGSN split

A.1 Introduction

In the PS CN domain the node that comprises the more user and control plane functions is undoubtedly the SGSN. The functional split of SGSN may be the primary target for decomposition. However the GGSN could be also decomposed into a server and a media gateway for smooth migration into R'00 and beyond. This alternative could be proposed as a next step solution of the SGSN split, after whole SGSN split issues are solved.

In the proposed architecture, as depicted in the figure A.1, the SGSN and the GGSN are decomposed into the server and the PS media gateway. The functional allocation between SGSN server, GGSN server and PS-MGW can be classified as follows.

Functions of the SGSN server:

- Session Management

- Mobility Management

- GTP-C termination

- MAP termination

- RANAP termination

- CDR handling

- Provision of Intercept Related Information (Lawful Interception)

- Media gateway selection

- CAP termination

- etc.

Functions of the GGSN server:

- Session Management

- Location Management (for MT call)

- GTP-C termination

- CDR handling

- Media gateway selection

- IP Packet control (RADIUS client, DHCP client and so on)

- etc.

Functions of the PS-MGW:

- GTP-U termination

- Quality of service provision

- Collection of usage information for charging

- Reporting of usage information on demand or event to the SGSN server

- Provision of Content of Communications (Lawful Interception)

- etc.

The servers control the PS-MGWs through the Mp interface following the H.248 standard. It is possible, as an operator and/or implementation option, to have a common MGW for the CS and PS CN domains, which allows for an efficient allocation of resources amongst both domains. In this case, the combined MGW may provide PSTN interworking functionality and operated as a MGW to the legacy PSTN for IP multimedia call.

The QoS resource allocation on the GGSN side requires further analysis.

# A.2   Logical Architecture
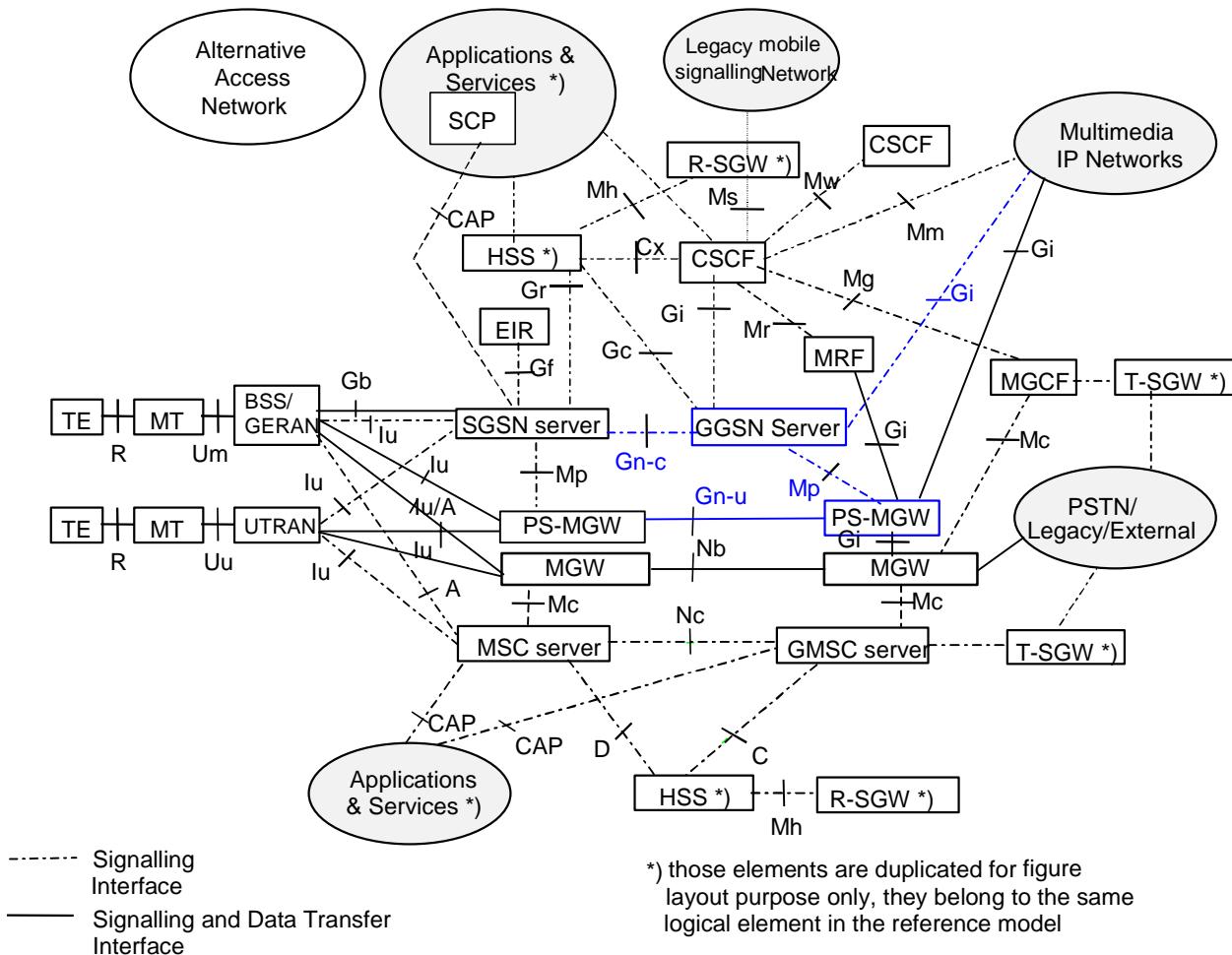
Figure A.1: Evolved logical architecture with GGSN server and PS-MGW

NOTE 1: A PS-MGW and associated MGW can be implemented as a single node. (Optional)

NOTE 2: The functionality and interfaces of the PS-MGW associated with GGSN may be different from the functionality and the interfaces of the PS-MGW associated with the SGSN.

NOTE 3: As an implementation option, to build a 2G+3G SGSN, the 2G-SGSN function may be ` ignalling with the SGSN server function.

NOTE 4: The following interfaces are also part of the R00 reference architecture, but are not shown for layout purposes only:

- between MSC's (including MSC server / MGW), E interface;

- between VLR's, G interface;

- between SGSN's, Gn interface;

- between CSCF and UE, Gm interface;

- between CSCF and PS-MGW, Gi interface;

- between MSC (or MSC server) and SGSN, Gs interface (optional).

In the proposed architecture, the control path is separated from the user data path, so that each path is split into control and user path; Iu-u, Iu-c, Gn-u, Gn-c, Gp-u, Gp-c and so on. The letter 'u' stands for 'user traffic' and 'c' stands for 'control plane'.

A.2.1   Functional Nodes

A.2.1.1   SGSN Server

The SGSN server handles all the ` ignalling interfaces of an R'99 SGSN, including the GTP-C protocol on the Gn_c and Gp_c interface and RANAP protocol on the Iu_c interface. It controls the PS-Media Gateway through the Mp interface following the H.248 standard.

Split architecture should support GPRS for GSM, but how to interconnect BSS and PS CN still needs further discussions in a sense that control plane and user plane would not be clearly separated on Gb interface. So which node between SGSN server and PS-MGW will be connected to BSS is not determined yet at the moment

A.2.1.2   GGSN Server

The GGSN server handles all the signalling interfaces of an R'99 GGSN, including the GTP-C protocol on Gn_c and Gp_c interface. It controls the PS-MGW through the Mp interface following the H.248 standard.

The GGSN server may act as a DHCP client and RADIUS client with the external IP network.

A.2.1.3   Packet Switching – Media Gateway (PS-MGW)

The PS-MGW handles the user plane for GPRS. It terminates the GTP-U tunnels from the PS-MGW supervised by SGSN server over Gn_u and Gp_u interface.

The PS-MGW is controlled either by the GGSN server or by the SGSN server through the Mp interface following the H.248 standard.

The PS-MGW can be combined with a MGW for CS domain, e.g. to allow for dynamic sharing of resources between the PS and CS domain

A.2.2   Interfaces

Only interfaces, which are newly introduced with splitting the GGSN, are mentioned in this section. Interfaces that are not described here or elsewhere in this TR conform to their definition in the relevant specifications.

The protocols GTP-U, GTP-C, RANAP and BSSGP referred to in the following subclauses conform to their current specifications and are not impacted by the decomposition of the SGSN and GGSN.

A.2.2.1   GGSN server – PS-MGW(Mp) (Iu Mode Only)

The PS-MGW is controlled by the GGSN server through the Mp interface. The Mp interface supports the MeGaCo/H.248 protocol, with GPRS-specific extensions. This interface belongs to the control plane.

A.2.2.2   BSS – PS CN (Gb) (Gb Mode Only)

With some open issues, the Gb interface needs further discussions, thus it is FFS.

A.2.2.3   SGSN server – GGSN server (Gn_c, Gp_c) (Iu Mode Only)

In Iu mode, the Gn_c interface between the SGSN server and the GGSN server supports the GTP-C protocol and belongs to the control plane.

The Gp_c interface provides the same functionality as the Gn_c interface, except that it applies only when the SGSN server and the GGSN server belong to different PLMNs.

A.2.2.4   Inter PS-MGW (Gn_u, Gp_u) (Iu Mode Only)

The Gn_u interface between the PS-MGW controlled by SGSN server and the PS-MGW controlled by GGSN server support the GTP-U protocol. This interface belongs to the user plane.

The Gp_u interface provides the same functionality as the Gn_u interface, except that it applies only when each PS-MGW belongs to different PLMNs.

A.2.2.5   Gn interface for inter SGSN procedures

Interfaces related to SGSN intersystem change (UMTS to/from GSM) are FFS.

The case where the MS moves between GSM cells served by two different nodes is FFS.

When the MS moves between UMTS cells served by two different SGSN servers:

-   the Gn_c interface between SGSN servers supports the GTP-C protocol.

-   the Gn_u interface between PS-MGW supports the GTP-U protocol.

A.3   Benefits and Drawbacks

With the decomposition of the GGSN, additional advantages are possible.

-   The PS-MGW associated with SGSN and the PS-MGW associated with GGSN could be easily integrated into a single node.

-   The PS-domain media gateway and the CS-domain media gateway could be integrated for more efficient resource allocation.

-   With the GGSN split, GGSN server may not be tightly coupled with PS-MGW. Even in the case of a GGSN change, the same GGSN server could control the newly assigned PS-MGW.

A.4   Open Issues

With the GGSN split, the following issues are to be solved.

-   Interoperability with GPRS (Gb mode only), including the interaction between the SGSN server (or PS-MGW) and BSS

-   Decomposition of QoS resource

-   Handling QoS messages in GGSN, including RSVP signalling

-   Investigate how to merge PSTN interworking functionality into PS-MGW

-   Further analysis on GTP-C protocol to be used for Mp interface

-   Investigate how to support Ipv6

-   Decomposition of Mobile IP functionality into GGSN server and PS-MGW

-   etc

Annex B (informative): Change History

Document history			
V0.0.0	2000-08	Document created	
V0.1.0	2000-08	Modifications according to drafting meeting in Stockholm, 22-24 August 2000. Documents included: S2S-000015, S2S-000017 and S2S-000019.	
V0.2.0	2000-09	Modifications according to drafting session in Bristol, 5 September 2000. Documents included: S2S-000033, S2S-000037, S2S-000038, S2S-000042, S2S-000043, S2S-000044 and S2S-000045.	
V0.3.0	2000-11	Modifications according to drafting meeting in Vancouver, 17-19 October 2000. Documents included: S2S-000051 to S2S-000054, S2S-000059 to S2S-000061, S2S-000066, S2S-000068, S2S-000070, S2S-000074, S2S-000079 to S2S-000083, S2S-000085, S2S-000087 to S2S-000090, S2S-000092, S2S-000094 to S2S-000097, S2S-000099, S2S-000100, S2S-000102 to S2S-000105.	
V0.4.0	2000-11	Modifications according to drafting session in Makuhari, 14-15 November 2000. Documents included: S2S-000117, S2S-000122, S2S-000128, S2S-000133, S2S-000136, S2S-000138, S2S-000139, S2S-000140, S2S-000143, S2S-000144, S2S-000146, S2S-000147, S2S-000149.	
V1.0.0	2000-11	No changes as compared to v0.4.0.	
V1.1.0	2001-01	Modifications according to drafting session in Los Angeles, 24-25 January 2001. Documents included: S2S-000126, S2S-000151, S2S-000153, S2S-000163, S2S-000166 to S2S-000168, S2S-000175, S2S-000178 to S2S-000183, S2S-000186, S2S-000189 to S2S-000192.	
v.2.0.0	2001-03	Version 2.0.0, same technical content as v.1.1.0	
v.4.0.0	2001-04	Version 4.0.0, same technical content as v.2.0.0. Reformatted into 3GPP TR format. Addition of an editorial note in the "forward" section to clarify that the Feasibility Study and this TR are closed.	

History

Document history		
V4.0.0	March 2001	Publication