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Sub-part 2: System Operation Overview

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 1, sub-part 2 of a multi-part deliverable. Full details of the entire series can be found in ETSI TS 102 744-1-1 [i.11].

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

This multi-part deliverable (Release 1) defines a satellite radio interface that provides UMTS services to users of mobile terminals via geostationary (GEO) satellites in the frequency range 1 518,000 MHz to 1 559,000 MHz (downlink) and 1 626,500 MHz to 1 660,500 MHz and 1 668,000 MHz to 1 675,000 MHz (uplink).

1 Scope

The present document provides an overview of the Family SL system operation, and describes fundamental UMTS elements such as mobility management, numbering and addressing, and idle mode behaviour as they apply to the Family SL satellite network. In general, these elements are the same for both terrestrial UMTS and the satellite network. Where appropriate, references to 3GPP documents are given, otherwise the text highlights the areas where the terrestrial UMTS and Family SL elements differ.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 123 003: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Numbering, addressing and identification (3GPP TS 23.003 Release 4)".

[2] ETSI TS 123 060: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); General Packet Radio Service (GPRS); Service description; Stage 2 (3GPP TS 23.060 Release 4)".

[3] ETSI TS 123 122: "Universal Mobile Telecommunications System (UMTS); Non-Access-Stratum functions related to Mobile Station (MS) in idle mode (3GPP TS 23.122 Release 4)".

[4] ETSI TS 125 413: "Universal Mobile Telecommunications System (UMTS); UTRAN Iu interface Radio Access Network Application Part (RANAP) signalling (3GPP TS 25.413 Release 4)".

[5] ETSI TS 102 744-1-4: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 4: Applicable External Specifications, Symbols and Abbreviations".

[6] Recommendation ITU-T E.164: "The international public telecommunication numbering plan".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 122 101: "Universal Mobile Telecommunications System (UMTS); Service aspects; Service principles (3GPP TS 22.101 Release 4)".

[i.2] ETSI TS 123 221: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Architectural requirements (3GPP TS 23.221 Release 4)".

[i.3] ETSI TS 124 007: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Mobile radio interface signalling layer 3; General Aspects (3GPP TS 24.007 Release 4)".

[i.4] ETSI TS 124 008: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (3GPP TS 24.008 Release 4)".

[i.5] ETSI TS 125 331: "Universal Mobile Telecommunications System (UMTS); Radio Resource Control (RRC) protocol specification (3GPP TS 25.331 Release 4)".

[i.6] ETSI TS 133 102: "Universal Mobile Telecommunications System (UMTS); 3G security; Security architecture (3GPP TS 33.102 Release 4)".

[i.7] Recommendation ITU-T E.212: "The international identification plan for public networks and subscriptions".

[i.8] ETSI TS 122 060: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); General Packet Radio Service (GPRS); Service description; Stage 1 (3GPP TS 22.060 Release 4)".

[i.9] ETSI TS 122 011: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Service accessibility (3GPP TS 22.011 Release 4)".

[i.10] ETSI TS 125 304: "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) procedures in idle mode and procedures for cell reselection in connected mode (3GPP TS 25.304 Release 4)".

[i.11] ETSI TS 102 744-1-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 1: Services and Architectures".

[i.12] ETSI TS 102 744-3-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 1: Bearer Control Layer Interface".

[i.13] ETSI TS 102 744-3-2: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 2: Bearer Control Layer Operation".

[i.14] ETSI TS 102 744-3-5: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 5: Adaptation Layer Interface".

[i.15] ETSI TS 102 744-3-6: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 6: Adaptation Layer Operation".

[i.16] ETSI TS 102 744-3-7: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 7: NAS Layer Interface Extensions for MBMS Services".

[i.17] ETSI TS 102 744-3-8: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 8: NAS Layer and User Plane Operation for MBMS Services".

[i.18] Recommendation ITU-T E.213: "Telephone and ISDN numbering plan for land mobile stations in public land mobile networks (PLMN)".

3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 102 744-1-4 [5], clause 3 apply.

4 Stratum introduction

For reference purposes, the functional aspects of the Family SL satellite network are shown in Figure 4.1. The Non-Access Stratum (NAS) groups together all protocols between the UE and the CN. The Access Stratum is divided into an Usl Stratum, which groups all protocols between the UE and RNS and an Iu Stratum, which groups all protocols between the RNS and CN. By definition the Usl and Iu Strata cross the Usl and Iu interfaces respectively.

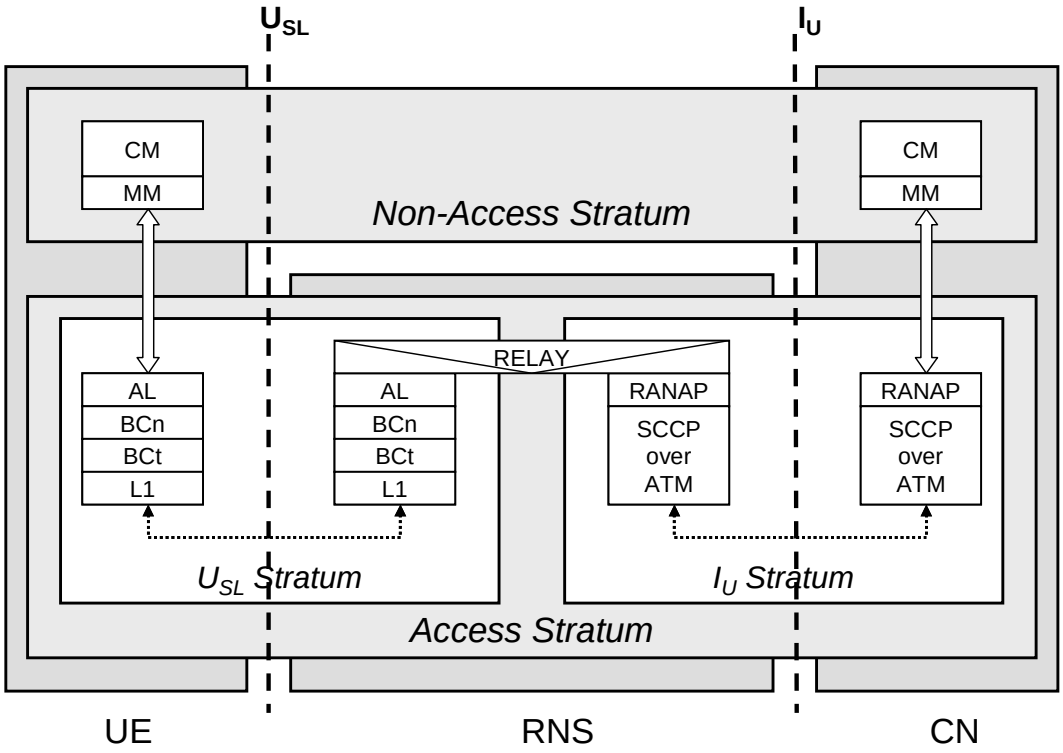

Figure 4.1: Stratum Divisions

5 Mobility Management (MM)

5.1 General principles

UMTS Layer 3 in the Control Plane contains two primary sublayers: Mobility Management (MM) and Connection Management (CM); see ETSI TS 124 007 [i.3], Figure 5.6. The CM sublayer controls access to circuit switched, packet switched, messaging, and other supplementary services. The MM sublayer is primarily responsible for tracking the location of the mobile subscribers within the satellite network and authorizing access to the network. MM provides services to entities in the CM sublayer (i.e. CM messages are transported by MM).

The MM sublayer contains two protocol entities: GPRS Mobility Management (GMM) for the PS domain and Mobility Management (MM) for the CS domain. There is one instance of GMM and one instance of MM in both the UE and the network (SGSN and MSC respectively).

As shown in Figure 5.1, the MM sublayer is entirely contained within the Non-Access Stratum. GMM and MM procedures and the contents of messages (PDUs) are fully transparent to the Access Stratum. Since the CM sublayer uses services from the MM sublayer, Call Control (CC), Session Management (SM), GPRS Short Message Service (GSMS) and Supplementary Service (SS) messages and procedures are also transparent to the Access Stratum.

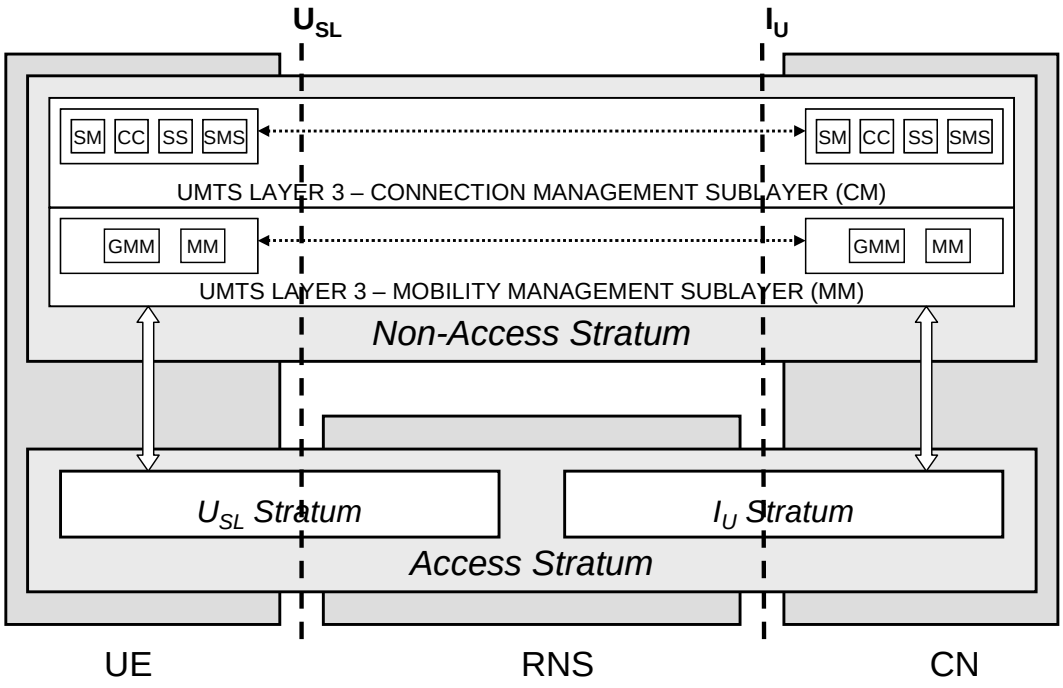

Figure 5.1: UMTS Layer 3 in Non-Access Stratum

5.2 RRC States (Idle and Connected Mode)

In terrestrial UMTS, the terms "idle mode" and "connected mode" refers to states of the Radio Resource Control (RRC) protocol layer (see ETSI TS 125 331 [i.5]). The RRC protocol [i.5] is not directly implemented in the satellite network; however, the Adaptation Layer (specifically the REGM entity, see ETSI TS 102 744-3-5 [i.14]) is responsible for maintaining the equivalent RRC state machine.

In the satellite network context, the RRC state (or mode) refers to the presence or absence of a UE-Specific Signalling connection between the UE and the RNC. This connection is established at the (successful) conclusion of the Registration procedure and released at the conclusion of the Deregistration procedure.

There are two main RRC states illustrated in Figure 5.2 and defined as follows:

- RRC-IDLE: no UE-Specific Signalling connection is established between UE and RNC.
- RRC-CONNECTED: a UE-Specific Signalling connection is established between the UE and the RNC which is serving the UE (the "Serving RNC" or SRNC).

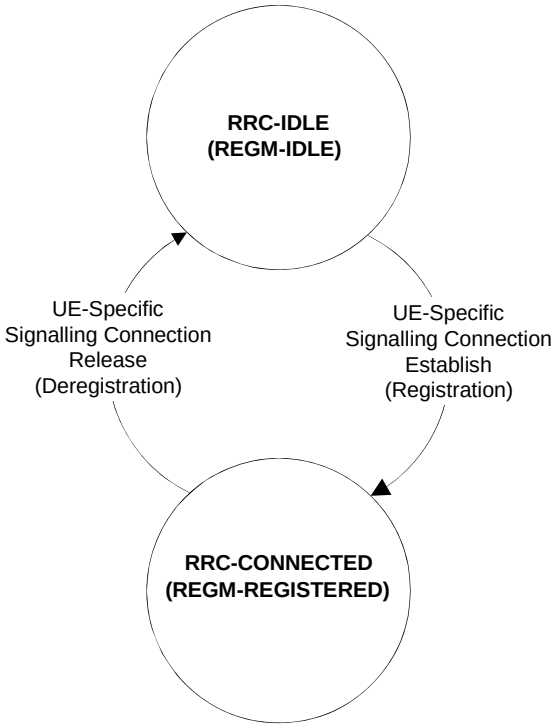

Figure 5.2: Equivalent RRC States in the satellite network

5.3 UE and Network Operation Modes

A UE can operate in one of three modes:

- PS/CS Mode: The UE is attached to both the PS domain and CS domain, and the UE is capable of simultaneously operating PS services and CS services. This mode of operation is equivalent to the GSM GPRS Class-A mode of operation.
- PS mode: The UE is attached to the PS domain only and may only operate services of the PS domain. However, this does not prevent CS-like services to be offered over the PS domain. This mode of operation is equivalent to the GSM GPRS Class-C mode of operation.
- CS mode: The UE is attached to the CS domain only and may only operate services of the CS domain. However, this does not prevent PS-like service to be offered over the CS domain.

The satellite network may operate either in Mode I or Mode II, i.e. the Gs interface between the MSC/VLR and SGSN may or may not exist for the purpose of coordinating GMM and MM functions (i.e. Attach, Location/Routing Area Update, Paging, etc.). The network mode of operation (NMO) is indicated to the UE as part of the broadcast system information.

Based on the mode of operation indicated by the network, the UE can then choose whether it can attach to CS domain services, to PS domain services, or to both, according to its mode of operation [i.8]. Furthermore, based on the mode of operation, the UE can choose whether it can initiate combined update procedures or separate update procedures, according to its capabilities. The combined GMM/MM functions avoid the need to send both MM and GMM messages when the PS domain can pass the necessary information to the CS domain privately within the CN.

A UE operating in CS/PS mode may have two signalling connections to the CN: a CS signalling connection to the MSC/VLR and a PS signalling connection to the SGSN. Signalling connections have two components: an Iu connection (RNC to CN) and an UE-Specific Signalling Connection (UE to RNC). Even though two separate Iu connections are required for the CS and PS domains (i.e. Iu-CS and Iu-PS), a single UE-Specific Signalling Connection is used for both the PS and CS domain (see Figure 5.3). The Adaptation Layer is responsible for the routing of signalling to and from the correct domain.

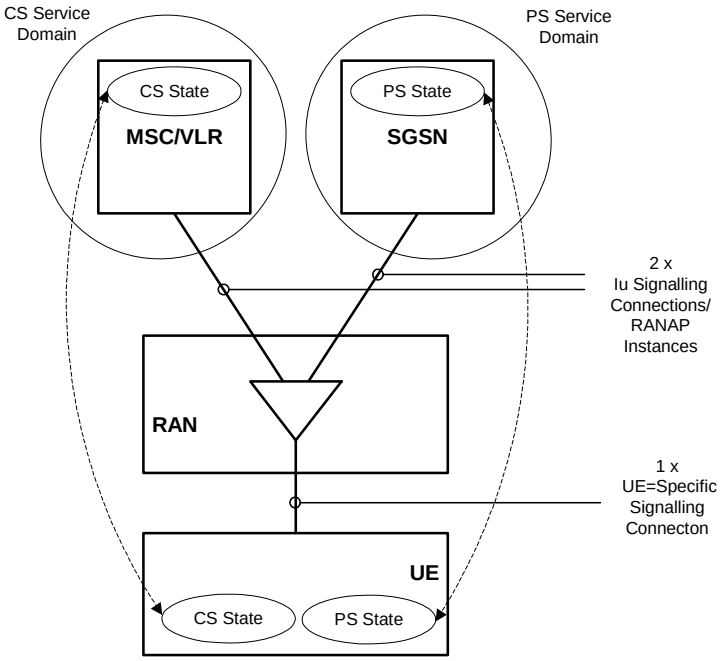

Figure 5.3: Relationship Between Service States and Signalling Connections

5.4 Mobility Management Service States

5.4.0 General

Each domain has its own service state machine (see Figure 5.3). An UE, that is supporting both CS services and PS services, has a CS service state machine and a PS service state machine. For every UE, there is a corresponding PS state machine and CS state machine in the SGSN and MSC respectively. The two peers of the service state machine are working independently to each other, although associated to the same UE. The UE-CN signalling aims to keep the peer entities synchronized.

5.4.1 PS Domain Service State Machine

5.4.1.0 General

The PS service state machine is called Packet Mobility Management (or PMM).

5.4.1.1 PMM-DETACHED State

In the PMM-DETACHED state there is no communication between the UE and the SGSN. The UE and SGSN PMM contexts hold no valid location or routing information for the UE. The UE MM state machine does not react on system information related to the SGSN. The UE is not reachable by a SGSN, as the UE location is not known.

In order to establish PMM contexts in the UE and the SGSN, the UE shall perform the (GMM) GPRS Attach procedure. When the PS signalling connection is established between the UE and the SGSN for performing the (GMM) GPRS Attach procedure, the state changes to PMM-CONNECTED in the SGSN and in the UE. A complete PS signalling connection is made up of two parts: an Iu connection (RNC to SGSN) and an UE-Specific Signalling Connection (UE to RNC).

5.4.1.2 PMM-IDLE State

In the PMM-IDLE state, a complete PS signalling connection is not established between the UE and SGSN, but the UE and SGSN have (previously) established PMM contexts. The UE location is known in the SGSN with an accuracy of a routing area. Paging is needed in order to reach the UE, e.g. for signalling. The UE shall perform the (GMM) Routing Area Update (RAU) procedure if the RA changes. Signalling towards the HLR is needed if the SGSN does not have a PMM context for this UE.

The UE and SGSN shall enter the PMM-CONNECTED state whenever the complete PS signalling connection is re-established between the UE and SGSN (required to initiate any GMM procedure).

While in the PMM-IDLE state, the SGSN or the UE may perform an implicit detach (i.e. without signalling), after which the local PMM state only changes to PMM-DETACHED. The SGSN may perform an implicit GPRS Detach any time after the UE Mobile Reachable Timer expires. The UE's PMM context in the SGSN is deleted, preferably after a certain (implementation dependent) time. The HLR may be informed about the deletion. The UE may perform an implicit GPRS Detach when, for example, the battery or USIM are removed, or the UE is switched off.

5.4.1.3 PMM-CONNECTED State

The UE location is known in the SGSN with an accuracy of a serving RNC. In the PMM-CONNECTED state, the location of the UE is tracked by the serving RNC. The UE performs the (GMM) Routing Area Update procedure if the RA changes (or if the RAI in the System Information broadcast changes).

When an UE and a SGSN are in the PMM-CONNECTED state, a complete PS signalling connection is established between the UE and the SGSN and GMM procedures can be initiated. In the SGSN, PS signalling connection release or changes the state to PMM-IDLE.

The UE shall enter the PMM-IDLE state when its PS signalling connection to the SGSN has been released or broken (i.e. the Iu-PS connection and/or the UE-Specific Signalling connection is released or broken). The signalling connection release is explicitly indicated by the RNC to the UE or detected by the UE.

After a signalling procedure (e.g. Routing Area Update), the SGSN may decide to release the PS signalling connection, after which the state is changed to PMM-IDLE. Completion of the (GMM) GPRS Detach procedure (either initiated by the UE or the SGSN) changes the state to PMM-DETACHED.

5.4.1.4 State Transitions and Functions

Figure 5.4 shows the PMM state machine in both the UE and SGSN. Note that the PMM-IDLE and PMM-CONNECTED states are independent of the Session Management state. The activation or deactivation of PDP Contexts by the SM entity does not affect the PMM state.

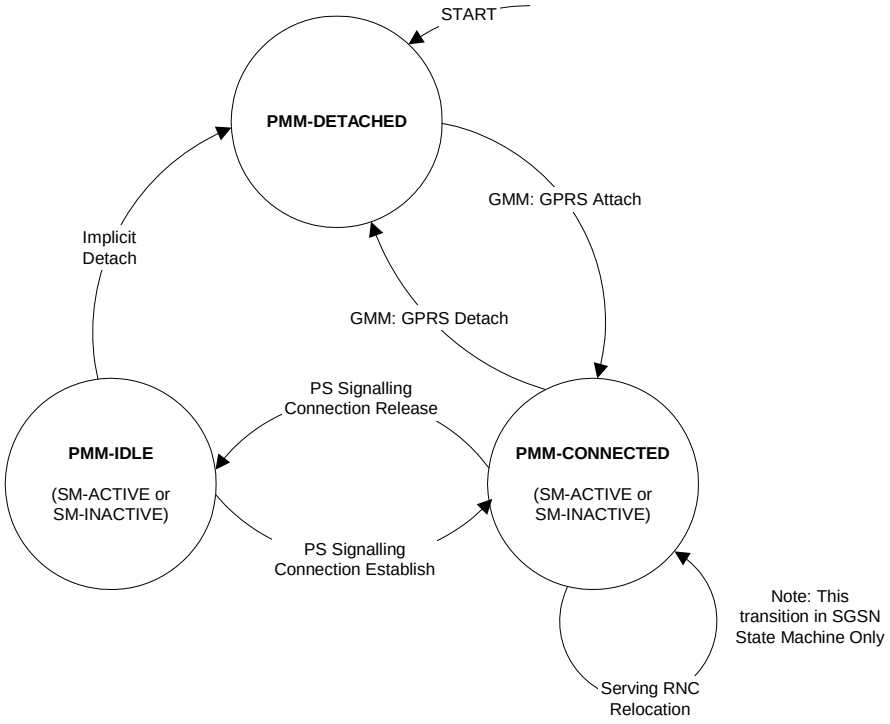

Figure 5.4: PS Domain Service State Machine in UE and SGSN

5.4.1.5 Periodic Routing Area Update Timer

Periodic Routing Area Updating (RAU) is used to periodically notify the availability of the UE to the network. The procedure is controlled in the UE by the Periodic RAU Timer, T3312. The value of timer T3312 is sent by the CN to the UE in the messages (GMM) Attach Accept and (GMM) Routing Area Update Accept. The value of the periodic RAU timer is unique within an RA. Upon expiry of the periodic RAU timer, the UE shall initiate the RAU procedure.

5.4.1.6 Mobile Reachable Timer

The Mobile Reachable Timer (MRT) function monitors the periodic RAU procedure in the SGSN. The MRT shall be slightly longer than the periodic RAU timer used by the UE. The MRT is stopped when the PMM-CONNECTED state is entered. The MRT is reset and started when the PMM-IDLE state is entered (i.e. the MRT is relevant to the PMM-IDLE state only).

If the Mobile Reachable Timer expires, the SGSN shall set the Paging Proceed Flag (PPF) to FALSE which inhibits the transmission of CS or PS paging messages by the SGSN to the UE. The PPF is set to TRUE when any activity from the UE is detected or when the UE first registers in an SGSN.

5.4.2 CS Domain Service State Machine

5.4.2.0 General

The CS service state machine has the same states as the PS service state machine (PMM) but the state transitions are different (see Figure 5.5). In the present document, the CS service state names follow the convention from ETSI TS 123 221 [i.2] and have the prefix "CMM".

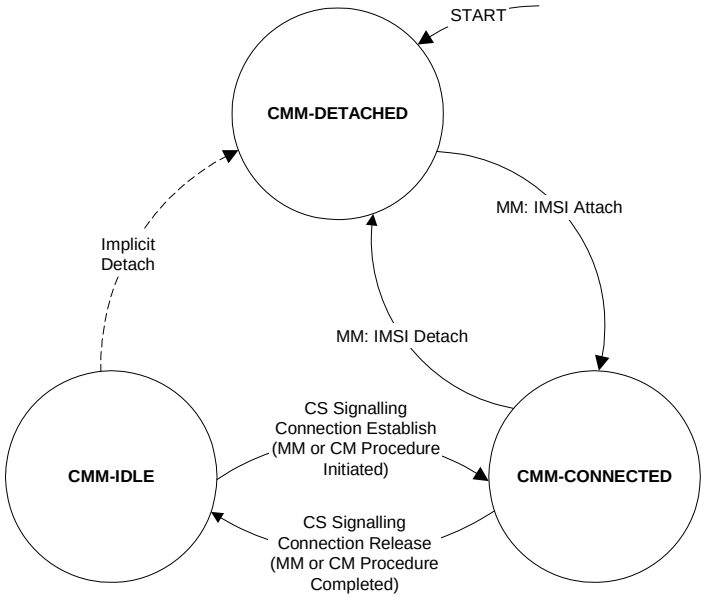

Figure 5.5: CS Domain Service State Machine in UE and MSC

5.4.2.1 CMM-DETACHED State

In the CMM-DETACHED state there is no communication between the UE and the MSC. The UE and MSC MM contexts hold no valid location information for the UE. The UE is not reachable by a MSC, as the UE location is not known.

In order to establish MM contexts in the UE and the MSC, the UE shall perform the IMSI Attach procedure. When the CS signalling connection is established between the UE and the MSC for performing the Attach procedure, the state changes to CMM-CONNECTED in the MSC and in the UE. A complete CS signalling connection is made up of two parts: an Iu connection (RNC to MSC) and an UE-Specific Signalling Connection (UE to RNC).

5.4.2.2 CMM-IDLE State

In the CMM-IDLE state, a complete CS signalling connection is not established between the UE and MSC, but the UE and MSC have established MM contexts. The UE location is known in the MSC with an accuracy of a location area. Paging is needed in order to reach the UE. The UE shall perform the Location Area Update procedure if the LA changes. Signalling towards the HLR is needed if the MSC does not have an MM context for this UE.

The UE and MSC shall enter the CMM-CONNECTED whenever the complete CS signalling connection is established between the UE and MSC for the purpose of initiating any MM procedure or CM procedure (e.g. initiating a call).

In the CMM-IDLE state, the UE may initiate an implicit Detach (i.e. without signalling) if the "ATT" flag broadcast in the Non-Access Stratum System Information indicates that the IMSI Detach procedure is not required. After performing an implicit Detach, the local CMM state changes to CMM-DETACHED.

5.4.2.3 CMM-CONNECTED State

In the CMM-CONNECTED state, a complete CS signalling connection is established between the UE and MSC, and the UE location is known in the MSC with an accuracy of a serving RNC. In the CMM-CONNECTED state, the location of the UE is tracked by the serving RNC. The UE does not perform the Location Area Update procedure, even if the LA changes as defined in ETSI TS 123 221 [i.2].

The UE shall enter the CMM-IDLE state whenever its CS signalling connection to the MSC is not required as the result of a MM procedure completing or a CM procedure completing (e.g. call finished). On transition from CMM-CONNECTED to CMM-IDLE, the CS signalling connection shall be released. The signalling connection release is explicitly indicated by the RNC to the UE or detected by the UE.

Completion of the IMSI Detach procedure (initiated either by the UE or by the MSC) causes the state to change to CMM-DETACHED.

5.5 Connection Maintenance

In UMTS, whenever an Iu connection (RNC to CN) is released (using the RANAP Iu Release elementary procedure), the corresponding radio interface connection (UE to RNC) is also released as defined in ETSI TS 125 413 [4]. Release of the Iu signalling connection for a particular CN domain (PS/CS) changes the service state for that domain from CONNECTED to IDLE in the CN. Similarly, release of the signalling connection over the radio interface changes the service state for that domain from CONNECTED to IDLE in the UE. In this way the service states in the CN and UE are always synchronized.

The mechanisms to establish and release the signalling connection over the satellite radio interface (the UE-Specific Signalling connection) are the Registration and Deregistration procedures. From the standpoint of efficiency in use of the satellite radio interface, it is undesirable to require the UE to register and deregister every time it is necessary to transition to and from the IDLE and CONNECTED service states. Therefore in the satellite network, the release of an Iu signalling connection does not necessarily imply the release of the UE-Specific Signalling connection.

Whenever an Iu signalling connection for a particular UE and CN domain is released, the RNC may consider releasing the UE-Specific Signalling connection to that UE only if it is no longer associated with an Iu signalling connection in any other CN domain. A configurable UE inactivity timer in the RNC determines the UE-Specific Signalling connection release policy once the RNC determines that the connection is no longer associated with any Iu signalling connections. The scope of the timer is a Location Area (i.e. different values may apply to different Location Areas).

If the UE inactivity timer is set to '0', then the RNC shall immediately initiate the Deregistration procedure. If the timer is set to any other value, then the RNC shall start the timer and initiate the Deregistration procedure on the expiry of the timer. The RNC shall reset the timer whenever it detects activity from the UE on either the Common Signalling connection (random access) or the UE-Specific Signalling connection.

In order to keep the service state machines in the CN and UE synchronized, whenever an Iu signalling connection is released but the UE-Specific Signalling connection is not released (due to the conditions above), the RNC shall send a SignallingConnectionRelease message to the UE over the UE-Specific Signalling connection. On receipt of the SignallingConnectionRelease message by the UE, the Adaptation Layer shall notify the appropriate Mobility Management entity (GMM or MM) and as a result the service state for the indicated CN domain shall change from CONNECTED to IDLE; the RRC state shall not change.

The RNC may also initiate the release of the UE-Specific Signalling connection to any UE which is idle (i.e. the UE inactivity timer is running) in order to free up signalling connection identifiers. UEs are selected as candidates for Deregistration on the basis of idle time duration (longest idle times selected first).

5.6 Mobility Management Procedures

The GMM protocol operates between the UE and SGSN and is supported by a UE which operates either in the PS/CS mode or the PS (only) mode. Similarly, the MM protocol operates between the UE and the MSC/VLR and is supported by a UE which operates either in the PS/CS mode or the CS (only) mode.

GMM and MM procedures for the satellite network are identical to those performed in UMTS; GMM and MM messages (PDUs) are transported through the Access Stratum between the UE and CN without modification. Refer to ETSI TS 123 060 [2], ETSI TS 124 007 [i.3], and ETSI TS 124 008 [i.4] for further information.

Although GMM and MM procedures are transparent to the Usl Stratum, the Adaptation Layer, like the RRC layer in UMTS, is responsible for notifying GMM and MM of particular events in order to keep the service state machines in the UE and CN synchronized, for example connection establishment (UE-Specific Signalling), resource assignment, start of security functions, paging, and connection failure. In addition, GMM and MM procedures may in turn cause the CN to invoke RANAP elementary procedures over the Iu interface which in turn invokes Adaptation Layer procedures over the Usl interface.

6 Numbering, Addressing and Identification

6.0 General

The Compact Syntax Notation (CSN.1) is used in this clause to describe the structure of information elements in protocol messages. See Annex B of ETSI TS 123 003 [1]. CSN.1 descriptions are typeset in Courier.

6.1 Non-Access Stratum

6.1.0 General

Numbering, addressing, and identification schemes in the Non-Access Stratum are the same as in the UMTS Non-Access Stratum, and, in general, ETSI TS 123 003 [1] applies in its entirety except where noted otherwise in this clause.

6.1.1 PLMN Identifier (PLMN ID)

ETSI TS 123 003 [1], clause 12.1 applies. The ITU assigns the shared MCC 901 for Global Mobile Satellite Systems (GMSS) - see Recommendation ITU-T E.212 [i.7]. A particular GMSS network is identified by its Mobile Network Code (MNC). Note that for GMSS, the MCC and MNC for GMSS do not relate to the country of domicile of the mobile subscriber.

```
<PLMN ID> ::= <MCC><MNC>
```

6.1.2 International Mobile Subscriber Identity (IMSI)

ETSI TS 123 003 [1], clause 2.2 applies.

6.1.3 Temporary Mobile Subscriber Identity (TMSI) and Packet Temporary Mobile Subscriber Identity (P-TMSI)

ETSI TS 123 003 [1], clauses 2.1, 2.4, and 2.7 refer.

6.1.4 International Mobile Station Equipment Identity/Software Version (IMEI/IMEISV)

ETSI TS 123 003 [1], clause 6.2 applies.

6.1.5 Location Area Identification (LAI)

ETSI TS 123 003 [1], clause 4.1 applies. The Location Area Identifier (LAI) is composed from the following information elements:

- Mobile Country Code (MCC): see definition for IMSI.
- Mobile Network Code (MNC): see definition for IMSI.
- Location Area Code (LAC): The LAC identifies a location area within a PLMN.

```
<LAC> ::= <OCTETSTRING(2)>
<LAI> ::= <MCC><MNC><LAC>
```

A satellite beam in a satellite UMTS network is the analogue of a "cell" in a terrestrial UMTS network, in the sense that cells and satellite beams are the smallest unit to which common radio resources are assigned. In addition, cells and satellite beams are the smallest possible areas in which a particular UE can be paged by the CN. For this reason in the satellite network a Location Area is equivalent to a satellite beam.

The LAC is arbitrarily divided into two components as follows:

```
<RNC AREA ID> ::= <BITSTRING(6)>
<SAT BEAM ID> ::= <BITSTRING(10)>
<LAC> ::= <RNC AREA ID><SAT BEAM ID>
```

The first component (<RNC AREA ID>) is a reference to a particular "RNC Area", which is defined as the set of satellite beams served by a single RNC. The second component (<SAT BEAM ID>) identifies a particular satellite beam within a RNC area. Every satellite beam (global, regional spot, and narrow spot) within a RNC Area is assigned a different value for the satellite beam ID.

The LAC is therefore a reference to the location of a UE (to the resolution of any satellite beam on any satellite) as well as a reference to the serving RNC. Note however that from the perspective of the UE and CN, the LAC is simply a 16-bit number; any arbitrary encoding schemes are not interpreted in the NAS. For example, the <RNC AREA ID> component of the LAC is not used by the CN for routing purposes.

This composition scheme does however ensure that there is no ambiguity in the LAI if more than one RNC serves a particular satellite beam and provides a degree of administrative convenience by allowing the spot beam and serving RNC to be determined directly from the LAC by inspection.

6.1.6 Routing Area Identification (RAI)

ETSI TS 123 003 [1], clause 4.2 applies. The RAI is composed from the following information elements:

- Location Area Identity (LAI): as defined in clause 6.1.5.
- Routing Area Code (RAC): The RAC identifies a routing area within a location area.

```
<RAC> ::= <OCTETSTRING(1)>
<RAI> ::= <LAI><RAC> = <MCC><MNC><LAC><RAC>
```

In terrestrial GPRS or UMTS, Location Areas are divided into Routing Areas in order to use the radio interface more efficiently when paging a particular UE (assuming that not all cells within a Location Area are served by the same SGSN). For circuit switched services, paging is done on the basis of LA, while paging for packet switched services are performed on the basis of RA.

A RA can either be the same as a LA, or the subset of one and only one LA (in other words, a RA does not span more than one LA). Given that a LA is equivalent to a spot beam (see clause 6.1.5) and since a spot beam cannot be subdivided any further, only the first definition of RA applies for the satellite network. Location Areas and Routing Areas in the satellite network are identical.

Since a RA is served by one and only one SGSN, a default value of 1 is used for the RAC in all Location Areas.

```
<RAI> ::= <LAI><RAC:1>
```

6.1.7 Mobile Station International PSTN/ISDN Number (MSISDN)

ETSI TS 123 003 [1], clause 3.3 applies. The MS International ISDN (MSISDN) numbers are allocated from the Recommendation ITU-T E.164 numbering plan [6], see also Recommendation ITU-T E.213 [i.18]. The MS international ISDN number is composed from the Country Code (CC), the National Destination Code (NDC),and the Subscriber Number (SN). The MSISDN is permanent subscriber data and is stored in the HLR, VLR and SGSN.

The composition of the MSISDN should be such that it can be used as a Global Title address in the Signalling Connection Control Part (SCCP) for routing messages to the HLR of the UE. The CC and NDC will normally provide such routing information, but if further routing information is required then it should be contained in the first few digits of the SN.

```
<MSISDN> ::= <CC><NDC><SN>
```

6.1.8 Mobile Station Roaming Number (MSRN)

ETSI TS 123 003 [1], clause 3.4 applies.

6.1.9 Mobile Station International Data Number

ETSI TS 123 003 [1], clause 3.5 applies.

6.1.10 IPv4 Address

ETSI TS 123 003 [1], clause 3.7 applies.

6.1.11 IPv6 Address

ETSI TS 123 003 [1], clause 3.8 applies.

6.1.12 Access Point Name

ETSI TS 123 003 [1], clause 9 applies.

6.2 Access Stratum (Usl Stratum)

6.2.1 UE Identification

6.2.1.0 General

The UE identification method used in the Usl Stratum depends on the RRC state.

6.2.1.1 RRC-IDLE Mode

In the RRC-IDLE Mode, no UE-Specific Signalling Connection is established between the UE and the RNC.
A Non-Access Stratum UE identifier is used in Registration messages to identify a particular UE.

The NAS UE identifier is provided to the Usl Stratum in the request from GMM or MM to establish the UE-Specific Signalling Connection. The NAS UE Identifier can be the TMSI, P-TMSI, or IMSI according to the precedence rules in ETSI TS 133 102 [i.6]. IMEI may also be used for initial identification for emergency calls when a USIM is not present in the UE.

6.2.1.2 RRC-CONNECTED Mode

In the RRC-CONNECTED mode, the Registration procedure has been successfully completed and a UE-Specific Signalling Connection has been established between the UE and the RNC. During the Registration procedure, the RNC assigns a unique Bearer Connection ID (BCnID) to the UE-Specific Signalling connection. The BCnID identifies the logical connection over the radio interface and the UE associated with the connection; it is a temporary identity which serves a similar function as the Radio Network Temporary Identity (RNTI) in a UMTS system.

6.2.2 Radio Resource to Network Layer UE Identity Association

For the purpose of paging coordination, the RNC shall maintain an internal routing table that associates the identity of a particular UE with the corresponding BCnID for the UE-Specific Signalling Connection to that UE.

The IMSI is transferred from the CN to the RNC using the RANAP Common ID elementary procedure. When an Iu connection is established, the CN performs the RANAP Common ID procedure towards the RNC as soon as the UE is identified.

If the UE identifies itself by a temporary ID (TMSI or P-TMSI) during the Registration procedure, then the routing table shall associate the temporary ID, and the corresponding BCnID for the UE-Specific Signalling Connection to that UE. The TMSI or P-TMSI in the routing table shall be associated with the IMSI as soon as it becomes available during the RANAP Common ID procedure.

The routing table entry for a particular UE is maintained only for the duration of the UE- Specific Signalling Connection (i.e. whilst the UE is in RRC-CONNECTED mode). When the mode for the UE changes from RRC-CONNECTED to RRC-IDLE (i.e. the UE-Specific Signalling Connection is released at the conclusion of the Deregistration procedure), the routing table entry for that UE shall be purged.

6.2.3 Logical Radio Interface Connection Identifiers

The UE-Specific Signalling Connection (Control Plane) and Data Connections (User Plane) are assigned Bearer Connection Identifiers (BCnID) by the RNC Adaptation Layer. The BCnID is then associated with a translated Bearer Connection Identifier (tBCnID) when the connection is attached to a specific Shared Access Bearer.

All communications which take place over the UE-Specific Signalling Connection or Data Connections use the tBCnID for addressing purposes.

6.2.4 Other Identifiers

6.2.4.1 Spot Beam ID

Spot Beam ID is an 8-bit identifier used primarily in the System Information (Bulletin Board, see clause 7). Every satellite beam (global, regional spot, and narrow spot) is assigned a different Spot Beam ID value. The scope of Spot Beam ID is a satellite and is therefore not unique throughout the satellite network (unlike the LAI).

For administrative convenience, Spot Beam ID may be identical or related to the <SAT BEAM ID> component of the Location Area Code (LAC, see clause 6.1.5), but it is not strictly necessary.

6.3 Access Stratum (Iu Stratum)

6.3.0 General

As with the Non-Access Stratum, the numbering, addressing, and identification schemes in the Iu Stratum are the same as for UMTS. ETSI TS 123 003 [1] and ETSI TS 125 413 [4] apply in their entirety. This clause highlights the areas where the UMTS and Family SL concepts differ.

6.3.1 PLMN Identifier (PLMN ID)

ETSI TS 123 003 [1], clause 12.1 applies.

6.3.2 CN Domain Identifier

ETSI TS 123 003 [1], clause 12.2 applies.

6.3.3 CN Domain Indicator

ETSI TS 125 413 [4], clause 9.2.1.5 applies.

6.3.4 RNC Identifier

ETSI TS 123 003 [1], clause 12.3 applies. A RNC node is uniquely identified by its RNC Identifier (RNC ID). The Global RNC Identifier is composed from the PLMN ID and the RNC ID.

```
<RNC ID> ::= <BITSTRING(12)>
<GLOBAL RNC ID> ::= <PLMN ID><RNC ID> = <MCC><MNC><RNC ID>
```

The RNC Identifier <RNC ID> refers to the same network entity as the <RNC AREA ID> component of the LAC (see clause 6.1.5). Only the former is used for CN to RNC routing purposes. The latter is an arbitrary construct and for administrative convenience the two identifiers could be identical or related, but it is not strictly necessary.

6.3.5 RNC Addresses

ETSI TS 123 060 [2], clause 14.12 applies.

6.3.6 Service Area Identifier (SAI)

ETSI TS 123 003 [1], clause 12.4 applies. In UMTS, the Service Area Identifier (SAI) is used to indicate the location of a UE to the CN. It is defined as an area covered by one or more cells belonging to the same Location Area. The Service Area Identifier (SAI) is composed from the Service Area Code (SAC) together with the PLMN ID and the LAC.

```
<SAC> ::= <OCTETSTRING(2)>
<SAI> ::= <PLMN ID><LAC><SAC>
```

In the satellite network, subdivisions of a LA (spot beam) are not possible in terms of the radio interface, but the SA concept is still employed to provide additional location information to the CN. A Location Area can be divided into arbitrary Service Areas provided that a SA is entirely contained within a LA.

The SAC is used to indicate the UE location within a particular geographical region. Up to 2^{16} non-overlapping geographical regions can be defined worldwide; each region is assigned a unique value of SAC. The definitions of these regions are arbitrary, at the discretion of the satellite network operator, and do not necessarily need to correspond with any geographical or political boundary. The SAC will be used primarily for emergency call routing, location based services, and billing applications, so it is likely that most defined geographical regions will correspond to countries or regions within countries. When used as a component of SAI, the special SAC value "0" denotes the entire geographical area covered by the associated LA (spot beam).

As a consequence of the composition method for the SAI, a Service Area in the satellite network (identified by its SAI) is the intersection of a spot beam coverage area (the LAC component) with a defined geographical area (the SAC component). The composition of Service Areas is shown in Figure 6.1.

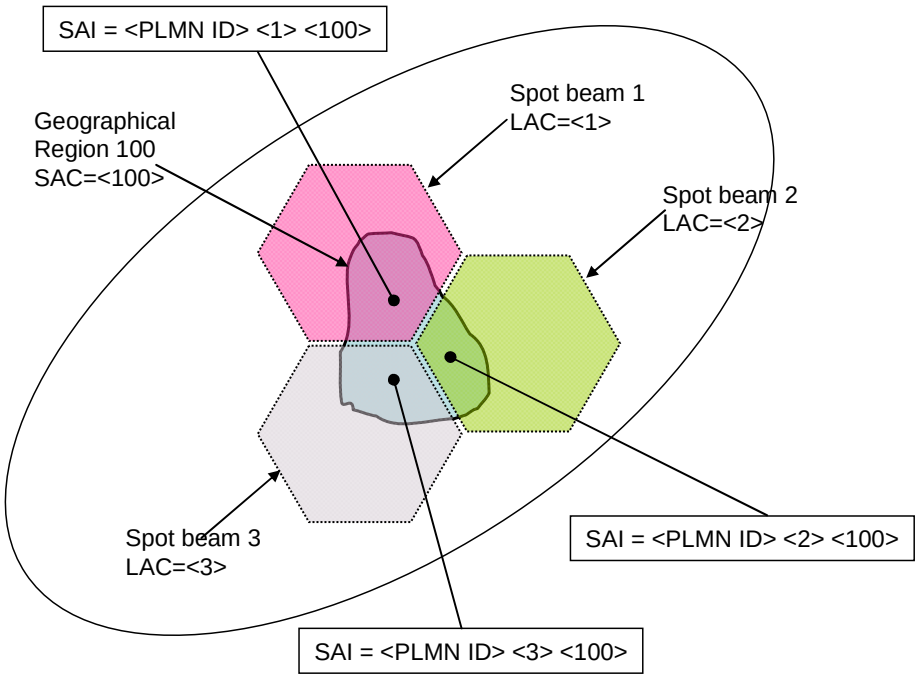

Figure 6.1: Composition of Service Areas

The RNC shall be capable of determining the correct SAC based on geographical position reports from the UE and providing this to the CN when commanded to do so as part of the RANAP Location Reporting Control elementary procedure. Note that the RNC can also report UE geographical position (latitude and longitude) to the CN for cases where country-region resolution is insufficient for a particular application.

The RNC and all CN applications shall consider the SAC a 16-bit index for use in look-up functions and shall not make any attempt to interpret any arbitrary meaning given to it.

6.3.7 Permanent NAS UE Identity

ETSI TS 125 413 [4], clause 9.2.3.1 and ETSI TS 123 221 [i.2], clause 6.16 refer. "Permanent NAS UE Identity" refers to either IMSI or IMEI. The IMSI is transferred from the CN to the RNC using the RANAP Common ID elementary RANAP procedure. When an Iu connection is established, the CN performs the RANAP Common ID procedure toward RNC as soon as the UE is identified (IMSI). The IMSI is stored in the RNC only for the duration of UE-Specific Signalling Connection (i.e. whilst the UE is in RRC-CONNECTED mode).

6.3.8 Temporary NAS UE Identity

ETSI TS 125 413 [4], clause 9.2.3.2 applies. "Temporary NAS UE Identity" refers to either TMSI or P-TMSI.

6.3.9 Radio Access Bearer Identity (RAB ID)

ETSI TS 125 413 [4], clause 9.2.1.2 applies. The Radio Access Bearer Identity (RAB ID) uniquely identifies the radio access bearer for a specific CN domain for a particular UE. The RAB ID is unique over one Iu connection.

The purpose of the RAB ID is to provide an association between a NAS data stream (UE to CN) and the Radio Bearer in the Access Stratum which carries the NAS data stream over the radio interface. The NAS data stream is identified by either the Stream Identifier (SI) for the CS Domain or the Network Service Access Point Identifier (NSAPI) related to a PDP Context for the PS Domain.

```
<SI> ::= <BITSTRING(8)>
<NSAPI> ::= <BITSTRING(4)>
<RAB ID> ::= { <SI> | 0000<NSAPI> }
```

The RNC shall maintain an internal routing table which relates the Permanent NAS UE ID to the corresponding BCnIDs of any active Data Connections and also the corresponding RAB IDs.

6.3.10 Iu Signalling Connection Identifier

ETSI TS 125 413 [4], clause 9.2.1.38 applies. The Iu Signalling Connection Identifier is a reference to an Iu signalling connection. It is assigned by the RNC during the RANAP Initial UE Message elementary procedure and the CN is required to store and remember it for the duration of the Iu connection. The Iu Signalling Connection Identifier can also be assigned by the CN during SRNS Relocation, in which case the RNC shall remember it for the duration of the Iu connection.

```
<IU SIG CONNECTION ID> ::= <BITSTRING(24)>
```

The RNC shall maintain an internal routing table which relates the Permanent NAS UE ID (IMSI) to the corresponding BCnID of the UE-Specific Signalling Connection and also the corresponding Iu Signalling Connection Identifiers.

6.3.11 Paging Area Identity

ETSI TS 125 413 [4], clause 9.2.1.21 applies. "Paging Area Identity" refers either to LAI or RAI. In either case, LAI (or RAI) in the satellite context uniquely addresses a satellite beam.

7 System Information

7.1 General Principles

The broadcast of System Information (SI) by the RNC and the corresponding reception of SI by the UE is a function of the Bearer Control Layer. The RNC broadcasts System Information on the Global Beam Common Channels as well as on all Primary Shared Access Bearers.

The System Information contains information elements related to the Access Stratum and the Non-Access Stratum:

- **AS System Information:** Access Stratum information which is required by the UE to identify and access the satellite network and determine the correct spot beam and PSAB on which to "camp on" and perform the Registration procedure with the RNC.
- **NAS System Information:** Non-Access Stratum (UMTS Mobility Management) information which is required by the UE to perform PLMN selection, determine its location (LA/RA), and to perform the (GMM or MM) Attach procedure with the CN.

In the UE, the Bearer Control Layer is responsible for forwarding the AS and NAS System Information to the Adaptation Layer whenever a new spot beam is selected as part of the PSAB Discovery procedure (see clause 8.2.2) or a change in the System Information for the current spot beam is detected. Similarly, the Adaptation Layer is responsible for forwarding the NAS System Information to the Non-Access Stratum at the conclusion of the PLMN Selection procedure (see clause 8.2.2).

7.2 System Information in Idle and Connected Modes

In the RRC-IDLE mode, when the UE camps on a Primary Shared Access Bearer (PSAB) in a particular spot beam, it receives all valid System Information (SI) for that spot beam on the PSAB common channel. The received SI is the "current system information" (see Figure 7.1).

When the UE-Specific Signalling Connection is established and the UE enters RRC-CONNECTED mode, the UE considers the broadcasted SI for the spot beam in which the establishment is made as the "current system information".

In RRC-CONNECTED mode, the Serving RNC (SRNC) shall control the current System Information for the UE. If the UE location (i.e. Location Area or Routing Area) changes as the result of spot beam handover or as the result of SRNS relocation, the SRNC shall send any applicable SI to the UE over the established UE-Specific Signalling Connection. The UE shall consider any new SI received from the SRNC on the established signalling connection as the "current system information".

When the UE-Specific Signalling Connection is released and the UE leaves the RRC-CONNECTED mode and enters RRC-IDLE mode, the spot beam selection process is performed again and the UE considers the broadcasted SI of the selected spot beam as the "current system information".

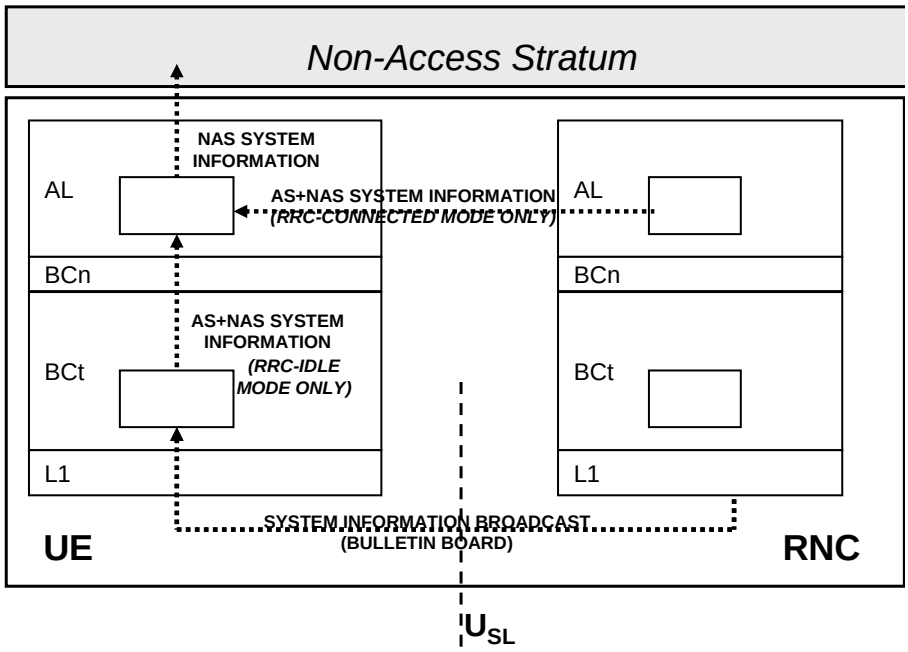

Figure 7.1: System Information Transport

7.3 System Information Elements

7.3.0 General

Information elements of the Bulletin Board (including System Information) are defined as part of the Bearer Control layer interface definition in ETSI TS 102 744-3-1 [i.12]. The information elements can be divided into three categories, based on their scope (i.e. the layer of the protocol stack in which they are relevant):

- Bulletin Board Information (Bearer Control Layer)
- Access Stratum System Information (Adaptation Layer)
- Non-Access Stratum System Information (UMTS Layer 3)

This clause briefly describes the latter two categories, as they are relevant to the UE Idle Mode behaviour described in clause 8.

7.3.1 Access Stratum System Information

7.3.1.0 General

Elements of the Access Stratum System Information control or affect Adaptation Layer behaviour, specifically the Registration Manager (REGM, see ETSI TS 102 744-3-6 [i.15]). The Access Stratum System Information set is divided into five subsets:

NOTE: Details of the following Information Elements and Attribute Value Pairs can be found in the Bearer Control layer interface specification: see ETSI TS 102 744-3-1 [i.12].

7.3.1.1 Primary Bearer

The Primary Bearer information element identifies the primary shared access bearer for a particular spot beam. Zero or more instances of this element may be present in the AS system information. If one or more instances are present, then this indicates that the current beam (i.e. the beam in which this system information is being received) is not suitable for performing the Registration procedure with the RNC and the UE shall select and tune to one of the identified PSABs. If there are no instances present, then the UE shall use the current beam to perform the Registration procedure with the RNC. More than one instance of the Primary Bearer element may be associated with a particular spot beam if it is necessary to direct the UE to different bearer frequencies depending on the UE class or a specific network (PLMN ID).

7.3.1.2 PLMN ID

The PLMN ID information element indicates the availability of a particular Public Land Mobile Network using the satellite radio access network. One or more instances of this element may be present in the AS system information.

If the current beam (i.e. the beam in which this system information is being received) is suitable for performing the Registration procedure with the RNC, then the system information shall contain one and only one instance of this element. The element identifies the PLMN ID of the "primary network", i.e. the network associated with the RNC that is transmitting the current PSAB in the current beam.

If the current beam is not suitable for performing the Registration procedure, then the system information shall contain one or more instances of this element. The first instance identifies the primary network. The second and subsequent instances (if any) identify networks which are equivalent to the primary network or secondary networks which can be accessed using the satellite radio access network but via a different RNC. In the latter case, there shall be a corresponding Primary Bearer system information element which also specifies the PLMN ID of the secondary network.

7.3.1.3 Access Control

The Access Control information element controls the initial access to the RNC. One instance of this element shall be present in the AS system information only if the current beam is suitable for performing the Registration procedure and access restrictions in the current beam are to be enforced. When present, only those UEs which are a member of at least one of the Access Classes which are permitted in the network according to the Access Control AVP shall attempt to access the RNC. A flag indicates whether or not the restrictions apply to UEs attempting an emergency call setup.

The Access (Control) Class is stored on the USIM in the UE. See ETSI TS 122 011 [i.9].

7.3.1.4 Spot Beam Map

The Spot Beam Map information element is a data structure which identifies one or more spot beams and provides their geographical boundaries. Zero or one instance of this element shall be present in the AS system information. If this element is present then the UE shall use the position-assisted spot beam selection method and the carrier scanning spot beam selection method otherwise (see clause 8.2.2.2.2).

7.3.1.5 Common Signalling Retry

The Common Signalling Retry information element defines the number of times that the UE may repeat the Registration procedure and the timeout between attempts. One instance of this element shall be present in the AS system information only if the current spot beam is suitable for performing the Registration procedure.

7.3.1.6 GPS Policy Info

The GPS Policy Info AVP informs the UE of the settings of GPS position-related security policies in the RNC. Zero or more instances of this element shall be present in the AS system information only if the current spot beam is suitable for performing the Registration procedure. If present, the UE may (optionally) use the policy information to determine whether or not the current GPS fix is suitable for gaining access to the RNC. RNC Policies are defined in ETSI TS 102 744-3-6 [i.15].

7.3.2 Non-Access Stratum System Information

Elements of the Non-Access Stratum System Information control or affect MM and GMM behaviour. The information set, called "Core Network System Information" in ETSI TS 124 008 [i.4], clause 10.5.1.12 is divided into three subsets:

- Common NAS System Information: Location Area Code (LAC)
- CS Domain Specific System Information: T3212 (Periodic Updating Timer), ATT flag (Attach/Detach Allowed)
- PS Domain Specific System Information: Routing Area Code (RAC), NMO flag (Network Mode of Operation, see clause 5.3)

8 UE Idle Mode Behaviour

8.1 NAS/AS Functional Divisions

The functional divisions between the UE Non-Access Stratum (NAS) and UE Access Stratum (AS) in RRC-IDLE mode are shown in Table 8.1. The NAS/AS divisions for the satellite network are the same as for UMTS with the exception that "spot beam selection and reselection" replaces the concept of "cell selection and reselection" in a terrestrial UMTS network.

Table 8.1: NAS/AS Idle Mode Functional Divisions

Idle Mode Process	UE Non-Access Stratum (UMTS Domain)	UE Access Stratum (Satellite Domain)
PLMN Selection and Reselection	Maintain the list of allowed PLMN types. Maintain a list of PLMNs in priority order according to ETSI TS 123 122 [3] select a PLMN using automatic or manual mode as specified in ETSI TS 123 122 [3] and request AS to select a spot beam belonging to this PLMN. Evaluate reports of available PLMNs from AS for PLMN selection. Maintain a list of equivalent PLMN identities.	Search for available PLMNs. Synchronize to a PSAB common channel to identify found PLMNs. Report available PLMNs with associated to NAS on request from NAS or autonomously.
Spot Beam Selection and Reselection	Indicate to the AS which PLMN is to be used initially in the search of a spot beam. Maintain lists of forbidden registration areas. Perform Location Area/Routing Area Update procedure as appropriate when system information indicates that the LA/RA has changed.	Detect and synchronize to a PSAB common channel. Receive and handle AS system information. Forward NAS system information to NAS. Search for a suitable spot beam belonging to the PLMN requested by NAS. Respond to NAS whether a spot beam that belongs to the requested PLMN and is suitable for registration is found or not. If a spot beam is found, it is selected to "camp on". [Maritime and Aeronautical UEs only: Periodically compare UE position information from GPS subsystem with spot beam information (broadcast as SI) to determine if spot beam reselection is required. Receive and handle AS system information for new spot beam. Forward NAS system information related to new spot beam to NAS.]

8.2 Idle Mode Procedures

8.2.1 Non-Access Stratum

The Non-Access Stratum Idle Mode procedures described in ETSI TS 123 122 [3] apply for the satellite network with appropriate changes in terminology ("spot beam" replaces "cell" wherever used).

8.2.2 Access Stratum (Usl Stratum)

8.2.2.0 General

ETSI TS 125 304 [i.10] describes the Access Stratum Idle Mode procedures. The general principles in ETSI TS 125 304 [i.10] apply to the satellite network. However the specific properties of the satellite link compared to the terrestrial link used in UMTS requires different methods for the satellite network.

There are two main UE Idle Mode procedures in the Non-Access Stratum, PLMN Discovery and PSAB Discovery. These procedures are described in general terms in this clause. For more information, see ETSI TS 102 744-3-6 [i.15].

8.2.2.1 PLMN Discovery

PLMN Discovery involves interaction between the Non-Access Stratum and the Adaptation Layer to determine if a particular UMTS network is available. When the UE is initialized, the NAS selects a PLMN according to the priority scheme defined in ETSI TS 123 122 [3]. The NAS then requests the Adaptation Layer to determine if a spot beam which belongs to the specified PLMN and is suitable for performing the Registration procedure with the RNC exists at the current location of the UE. Figure 6 and Figures 8 through 13 in ETSI TS 125 304 [i.10] specify a set of service primitives between RRC and the NAS for the purpose of PLMN selection control and NAS system information transport; these primitives are used in the satellite network as well, with the Adaptation Layer assuming the role of RRC.

When the PLMN Discovery procedure is initiated by the Non-Access Stratum, the Adaptation Layer in turn initiates the PSAB Discovery procedure, described in the next clause.

8.2.2.2 PSAB Discovery

8.2.2.2.1 Method

PSAB Discovery involves interaction between the Adaptation Layer and the Bearer Control layer to locate a Primary Shared Access Bearer (PSAB) which can be used for registration with the RNC. PSAB Discovery is also known as spot beam selection. The Adaptation Layer provides the Bearer Control Layer with a list of one or more PSAB frequencies. In response, the Bearer Control Layer tunes to each identified PSAB frequency and locks on to the PSAB with the highest signal quality and starts receiving the common control channel on this PSAB. The Bearer Control Layer then indicates which PSAB frequency (if any) was selected and also forwards the relevant Access Stratum and Non-Access Stratum System Information (see clause 7) to the Adaptation Layer.

The AS System Information informs the Adaptation Layer whether or not the "discovered" PSAB is suitable for registration with the RNC, or if it is necessary to select another PSAB and repeat the PSAB Discovery procedure again.

In the satellite network, a hierarchy of spot beams exists, with narrow spot beams overlaid on regional beams which are themselves overlaid on the global beam. The directive in the System Information may cause the UE to select a PSAB frequency which corresponds with a spot beam in the next tier of the hierarchy, depending on the operational configuration. Note however that the PSAB Discovery procedure is generic and makes no distinction between satellite beams of different types.

8.2.2.2.2 Spot Beam Selection Methods

The PSAB Discovery procedure supports spot beam selection by two methods: carrier scan and position-assisted. In the carrier scanning method, described earlier, the Bearer Control layer tunes in turn to all of the candidate PSAB frequencies identified by the Adaptation Layer and locks on to the PSAB with the highest signal quality. In the position-assisted method, the Adaptation Layer uses information about the geographical location of spot beam boundaries and the UE GPS position to select the most appropriate spot beam. The Adaptation Layer then specifies the identifying PSAB frequency of the selected beam to the Bearer Control layer. The position-assisted method shall be used whenever possible (i.e. when the Spot Beam Map information element is present in the System Information and the UE GPS position is available).

9 Sleep Mode

Sleep Mode is the satellite replacement for the terrestrial UMTS Discontinuous Reception (DRX) mode. In Sleep Mode the UE reduces power consumption by receiving and processing the forward channel only for small fractions of a regular interval of time. During the period the UE is "awake", the UE may receive Paging messages from the RNC.

There are two main differences between Sleep Mode and the Discontinuous Reception (DRX) mode defined for terrestrial UMTS. In terrestrial UMTS, DRX applies only while the UE is in the RRC-IDLE state and there may be different DRX parameters for the CS and PS service domains. In the satellite context, Sleep Mode applies to both the RRC-IDLE and RRC-CONNECTED states (REGM "IDLE" and "REGISTERED" states, respectively) and one set of parameters applies to both service domains.

NOTE: The AVP to configure sleep mode and the applicable parameters are defined in ETSI TS 102 744-3-1 [i.12] and ETSI TS 102 744-3-2 [i.13] respectively and are specified to the UE by the RNC either during or after the Registration procedure.

When and how often the UE can be in sleep mode depends largely on the PS and CS service state machines (see clause 5.4). In the PMM-CONNECTED (PS domain) and CMM-CONNECTED (CS domain) service states, a network-initiated signalling procedure or downlink data transfer occurs immediately without paging. In the PMM-IDLE and CMM-IDLE states, completion of the Paging procedure is required before any network-initiated signalling procedure or downlink data transfer can begin. Therefore, the UE may only enter Sleep Mode (or be in Sleep Mode) while in both the PMM-IDLE and CMM-IDLE states simultaneously.

Sleep Mode in the UE is controlled by the Bearer Control layer (see ETSI TS 102 744-3-2 [i.13]). Explicit communication between the UMTS Mobility Management sublayer (which maintains the PMM and CMM service state machines) and the Bearer Control layer for the purpose of coordinating Sleep Mode is not required. The transitions to and from Sleep Mode in the Bearer Control layer and the transitions between the CONNECTED and IDLE service states are related to UE activity (the transmission of any signalling or data by the UE). A consequence of the protocol stack model is that activity in the Bearer Control layer directly implies activity in higher layers. However, the inactivity timer in the Bearer Control layer which controls the transition to Sleep Mode shall be set longer than the inactivity timers in the MM sublayer (SGSN and MSC) which control the transition from the CONNECTED to the IDLE service state.

A UE in Sleep Mode is typically awake for one frame in 64 and is assigned by the RNC to one of 64 paging groups such that the distribution of UEs across all paging groups is uniform. There is typically one paging opportunity approximately every 5,12 seconds (64 frames of 80 ms each).

Annex A (informative): System operation

A.1 Introduction

A.1.1 Network Architecture

The satellite network provides UMTS circuit switched and packet switched communication services to mobile users at a variety of data rates. A UMTS network is partitioned into three main areas, the Core Network (CN), Radio Network Subsystem (RNS) and User Equipment (UE).

The RNS and more precisely the node within the RNS called the RNC (Radio Network Controller) controls the radio link to the UE. The CN provides the services, switching, and routing of traffic to and from the UE via the RNS. The UE contains the user's radio modem and services.

NOTE: In a terrestrial UMTS network the radio interface to the mobile users uses WCDMA. The satellite network provides the same UMTS services using the satellite radio interface which uses a TDM-TDMA/FDM physical layer.

Further details of the satellite network architecture and interfaces are provided in ETSI TS 102 744-1-1 [i.11].

The satellite radio interface does not use RRC (Radio Resource Control) protocol [i.5]. Instead, the Adaptation Layer provides the Non Access Stratum layer 3 Control Plane with equivalent services to those offered by the RRC.

A.1.2 Adaptation Layer

The Adaptation Layer that interfaces the satellite radio interface protocol stack with the UMTS protocols is presented in ETSI TS 102 744-3-5 [i.14] and ETSI TS 102 744-3-6 [i.15].

The following Adaptation Layer Entities are referred to in this clause:

- **REGM:** Registration Manager, responsible for establishing, maintaining and releasing UE specific signalling connections, reception and interpretation of System Information, idle mode procedures, paging notification (type 1) and GPS reporting/encryption.
- **GMMH:** GMM Service Access Point Handler, provides RRC-like services to the GMM agent in the Non Access Stratum.
- **MMH:** MM Service Access Point Handler, provides RRC-like services to the MM agent in the Non Access Stratum.
- **RBC:** Radio Bearer Control, handles all signalling related to the establishment, modification and release of radio bearers.

A.2 Example Call Flows

A.2.1 User Equipment Start up Sequence

The UE performs four procedures in sequence to gain access to UMTS services:

- the Public Land Mobile Network (PLMN) Discovery procedure;
- Primary Shared Access Bearer (PSAB) Discovery procedure;
- the Registration procedure with the Radio Network Controller (RNC); and
- the UMTS Attach procedure with the Core Network.

The PLMN Discovery procedure is used by the UE to select a suitable Network. This procedure is described in more detail in clause 8.2.2.1 and is followed by the PSAB Discovery procedure which allows the UE to select a Primary Shared Access Bearer, in a Regional or Narrow spot beam, which is suitable for performing the Registration procedure with the RNC.

The Registration procedure allows the UE to identify itself to a Radio Network Controller (RNC), report its geographical location and be allocated a dedicated radio-signalling connection to the RNC, known as a UE-Specific Signalling Connection. A single UE-Specific Signalling Connection to an RNC is permitted per UE. The UE-Specific Signalling Connection is equivalent to an RRC Connection in UTRAN terminology.

In the subsequent UMTS Attach procedure, the UE extends the UE-Specific Signalling Connection beyond the RNC towards one or both UMTS Core Network (CN) domains. This is achieved by setting up Iu Signalling Connections for this UE. The joining of a UE-Specific Signalling Connection (UE to RNC) with an Iu Signalling Connection (RNC to CN) allows the UE to exchange Non-Access Stratum (NAS) signalling with the CN. This logical connection between the UE and CN is known as a PS or CS Signalling Connection, depending on whether it addresses the Packet or Circuit Switched CN domain.

Via the PS or CS Signalling Connection, the UE may perform Mobility Management (MM) Connection Management (CM), Session Management (SM), Supplementary Services (SS) and Short Messaging Service (SMS) procedures, identify itself to the network, initiate calls and receive paging messages, etc.

For further information describing the relationship between RRC Connection and Iu Signalling Connection refer to ETSI TS 123 221 [i.2], clause 6.

The following clauses describe the selection of a suitable Primary Shared Access Bearer, Registration and UMTS Attach procedures.

A.2.2 Selection of Primary Shared Access Bearer

A.2.2.0 General

The following clauses introduce the spot beam concept of the satellite network and describe the selection of a suitable Primary Shared Access Bearer by the UE.

A.2.2.1 Spot Beam Hierarchy

Within the satellite network each satellite typically provides:

- one global beam, which covers all points on the earth surface with elevation towards the satellite above 10 degrees;
- a few 10's of wide spot beams (referred to as Regional Beams) covering the whole satellite field of view; and
- a few 100's of narrow spot beams (referred to as Narrow Beams), typically positioned over the land masses.

For the satellite network these different types of beams typically serve the following purposes:

- The Global Beam on each satellite is used in the forward direction (downlink to UE) to provide all UEs with various elements of system information via a Common Channel, most notably the frequencies used in the Regional Beams. The Global Beam is not used in the return direction.
- The Regional Beams are used in the forward direction to transmit a Primary Shared Access Bearer (at least one in each beam) from which the UEs receive additional system information regarding the initial access to the satellite network. At least one Bearer is allocated to a Regional Beam in the return direction if it is to be used for initial access.
- The Regional Beams may also be used to carry user traffic, either if the demand for traffic capacity is low and hence it is not economical to illuminate a Narrow Beam; or if the UE is located in an area that is not covered by a Narrow Beam at all. Traffic may initially be carried on the PSABs mentioned above but additional forward and return bearers may be allocated to carry traffic if required.
- The Narrow Beams primarily carry traffic and are activated as required. This limits the suitability of the Narrow Beams for initial access purposes.

A.2.2.2 Regional Beam Selection

The UE normally selects a Regional Beam based on GPS positioning information and spot beam boundary information ("spot beam maps") being transmitted on the Global Beam common channel. However, a carrier scanning selection method, based on received signal strength or signal quality, is also implemented in the UE as a fallback if spot beam maps are not transmitted on the Global Beam or GPS positioning information is not available. In the latter case the UE would need to scan all Primary Shared Access Bearers advertised on the Global Beam Common Channel.

A.2.2.3 Narrow Beam Access

Any of the Narrow Beams may or may not be illuminated at any one time, which imposes further constraints on the way the RNC manages the access to these beams. Generally, UEs signal their request for a service connection in the Regional Beam and the RNC would then initiate the Handover procedure to move the UE to the most suitable Narrow Beam for its current position (based on the most recent position report from the UE).

Under certain circumstances, e.g. if an area is not covered by a Regional Beam but is illuminated by a Narrow Beam (isolated Narrow Beam), or if the capacity of the Regional Beam is insufficient due to an extremely high number of user in a particular area, then the system information broadcast in the Regional Beam may direct the UE to select and use a Narrow Beam for initial access.

A.2.3 PSAB Selection Process

The UE typically selects a suitable Primary Shared Access Bearer as follows:

1) The UE tunes to the Global Beam Common Channel and reads the list of available Primary Shared Access Bearers together with the spot beam boundary information (both for Regional as well as isolated Narrow Beams, if applicable).

2) Based on GPS position information the UE uses the spot beam boundary information (spot beam maps) and knowledge of its own position to select a Regional Beam (or Narrow Beam if no Regional Beam is available to cover the location of the UE) from the above list and to tune to the frequency of the Primary Shared Access Bearer.

3) In overlap areas served by more than one beam, the UE performs a scan of all suitable beams and selects the one providing the highest signal/noise ratio or makes a selection based on preference control information in the spot beam boundary information.

4) In the event that no GPS position information or spot beam maps are available, the UE performs a scan of the Primary Shared Access Bearer frequencies of all the beams listed on the Global Beam Common Channel and select the one providing the highest signal/noise ratio.

5) After successfully acquiring a Primary Shared Access Bearer the UE reads the System Information transmitted on this bearer.

6) If this Shared Access Bearer does not contain a list of Primary Shared Access Bearers in Narrow Beams, then the UE remains on the currently selected bearer and carries out the random access procedure described in clause A.2.4.

7) If this Shared Access Bearer does contain a list of Primary Shared Access Bearers in Narrow Beams, then the UE determines from this list if there is a suitable Narrow Beam covering the location of the UE and tunes to the frequency of the Primary Shared Access Bearer.

8) In overlap areas served by more than one beam, the UE selects a suitable beam based on signal quality or preference control information in the spot beam boundary information.

9) In the event that no GPS position information is available, the UE performs a scan of all beams signalled in the list obtained during step 7 select the one providing the highest signal/noise ratio.

10) The UE now remains on the currently selected bearer and carries out the Registration procedure as described in clause A.2.4.

The above procedure is illustrated in Figure A.1.

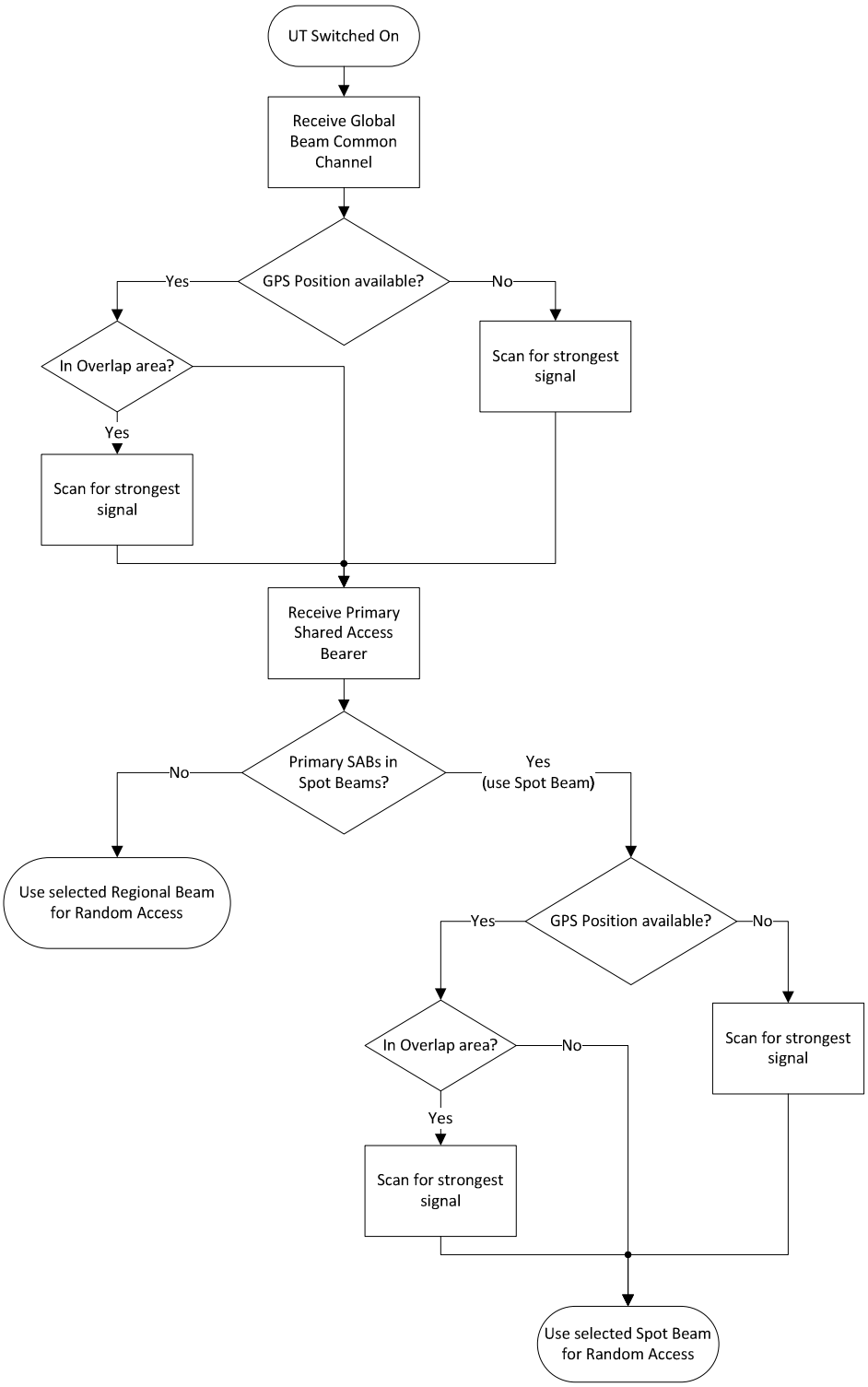

Figure A.1: Beam Selection Process at UE

A.2.4 Registration on the Satellite Network

The procedure illustrated in Figure A.2 presents the exchange of messages required for the User Equipment (UE) to initiate communication with a Radio Network Controller (RNC) and to be allocated a UE-Specific Signalling Connection. The registration procedure needs to be performed before the UE can send signalling messages to the CN.

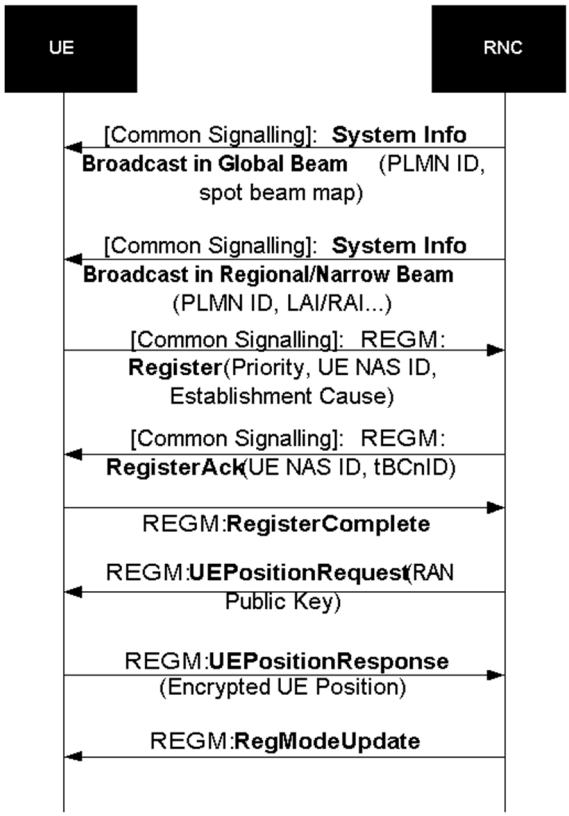

Figure A.2: Registration

When the UE is finally camped on a PSAB it monitors the return schedule transmissions to identify a suitable opportunity to transmit a random access burst containing a Register Protocol Data Unit (PDU) to the RNC. The Register PDU identifies the UE to the RNC (when not inhibited by Access Class or SIM card control mechanisms) by including its NAS ID (IMSI, TMSI, P-TMSI or IMEI in the case of Emergency Call without SIM/USIM).

If the RNC successfully accepts this Register PDU it responds with a RegisterAck PDU that allocates a UE-Specific Signalling Connection for subsequent signalling messages. The UE indicates that it has received the RegisterAck message by sending the RegisterComplete message on the newly established UE Specific Signalling Connection.

The RNC may, depending on RNC policy, then request the UE to send its GPS position to the RNC. This position report is protected from interception using a public key encryption algorithm (the public key either being sent to the UE in the position request message from the RNC or drawn from a predefined array of keys stored in the UE). The encrypted position report returned from the UE in the response allows the RNC to determine if the UE is permitted to use the satellite network services in the service area corresponding to its geographical position. If this is the case then the RNC accepts the UE and allow it to proceed with the UMTS Attach by responding with a RegModeUpdate message.

A.2.5 Attach Procedure and Combined Procedures

A.2.5.0 General

As a result of Registration, a signalling connection is established allowing the UE and RNC to exchange signalling, but at this stage the Core Network (CN) is not yet aware of the presence of the subscriber in the network. In order to receive paging messages and to establish mobile originated and terminated connections for user traffic, the UE needs to Attach to the Core Network.

The UMTS Release 4 Core Network consists of two independent network domains with separate equipment, namely the packet switched (PS) and circuit switched (CS) domains. Users wishing to establish circuit switched calls or packet switched sessions need to Attach to the appropriate Core Network domain.

Although the two network domains are functionally separate, the network may optionally be configured to permit combined CS and PS procedures. Combined procedures permit the reduction of signalling load on the satellite radio interface, for example by allowing the users to carry out a combined Attach to both the CS and PS domains using one signalling sequence directed to the PS domain. The availability or otherwise of combined procedures is advertised to users in the broadcast system information using the information element "Network Mode of Operation(NMO)". When the network is in NMO-I, combined procedures can occur. In NMO-II, combined procedures are not permitted.

For further explanation of the use of combined procedures and Network Mode of Operation, please refer to ETSI TS 124 008 [i.4], clause 4.1.1.2 and ETSI TS 123 060 [2], clause 6.3.

A.2.5.1 IMSI Attach Procedure

The IMSI Attach procedure (also refer to ETSI TS 124 008 [i.4], clause 4.4.3) is initiated by the UE in order to gain access to UMTS circuit switched services, as illustrated in Figure A.3. If the UE is in CS/PS mode of operation and the network is in NMO-I, the UE may instead use the GPRS Attach procedure to execute a combined Attach to both the CS and PS domains, thus reducing the signalling load.

To gain access to UMTS Circuit Switched services using IMSI Attach, the UE needs to indicate to the serving MSC/VLR that it is active. The UE identifies itself using the subscriber's globally unique subscriber identity number, the IMSI (recorded in the user's subscriber identity module, USIM) or alternatively it identifies itself using the subscriber's temporary identity number the TMSI and the previous LAI (Location Area Identity) where it was located (if available from a previous session). Where possible, a TMSI is allocated to a user in place of the IMSI for signalling over the satellite radio interface for reasons of subscriber confidentiality. The TMSI is changed regularly, i.e. at each Location Area Update procedure.

An InitialDirectTransfer message is sent by the UE via the previously established UE-Specific Signalling Connection with the RNC (see clause A.2.4). The InitialDirectTransfer has the dual function of establishing a signalling connection from the UE to the serving MSC/VLR via the RNC and transferring the first mobility management (MM) message of this transaction to the MSC/VLR (in this case the MM message to the CN is LocationUpdatingRequest (type="IMSI Attach").

NOTE: The requirement for UEs to undertake IMSI Attach and Detach procedures is advertised in the broadcast system information.

This message identifies the subscriber to the CS Core Network using their IMSI or (TMSI where available). The MSC/VLR response is to authenticate the subscriber using the Authentication procedure. The conditions for undertaking Authentication are operator configurable but typically Authentication would be triggered each time (or once in a configurable number of times, also known as "Selective Authentication") a signalling connection between the CN and UE is established. In the example presented, the Authentication procedure is triggered.

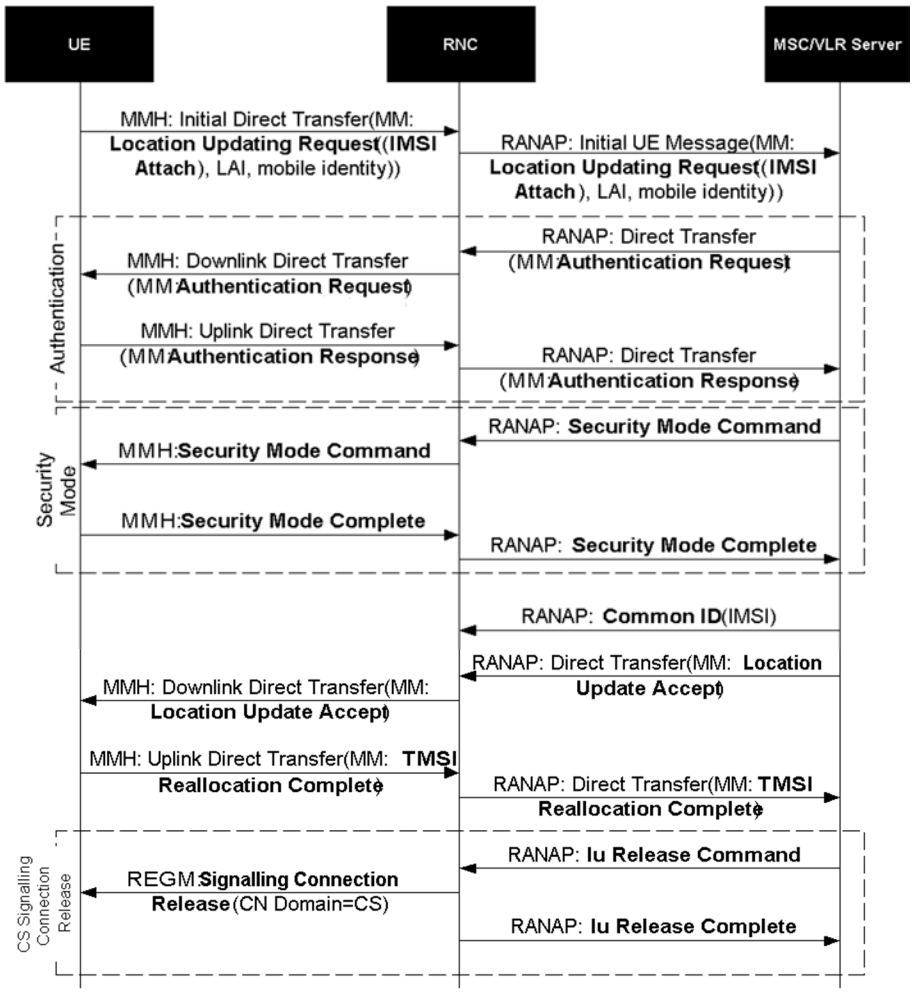

Figure A.3: IMSI Attach

The Authentication procedure has three functions, firstly to identify the IMSI and establish that its user is genuine, secondly to allow the UE to establish that the network is genuine (Mutual Authentication) and thirdly to provide ciphering and integrity keys to the UE for subsequent security procedures.

A successful Authentication procedure consists of an AuthenticationRequest from the MSC/VLR passed to the UE that in turn responds with an AuthenticationResponse. The MSC/VLR checks whether the response from the UE is as expected and if successful it proceeds.

A further aspect of security follows, whereby the MSC/VLR commands the UE to switch on Ciphering and Integrity Protection over the satellite radio interface. A successful exchange of SecurityModeCommand and SecurityModeComplete ensures that subsequent exchanges between the UE and RNC across the radio interface are ciphered to prevent eavesdropping. In addition, signalling messages may be subject to Integrity Protection by which each signalling message is appended with a 32 bit digital signature that is checked by its recipient to determine whether the message is genuine, i.e. has not been tampered or substituted by an intermediary. Integrity Protection is mandatory for all signalling except in a small number of cases (such as Emergency Calls without a SIM) so in general Authentication would be performed to produce the required keys. However it is up to the network to decide how long a particular key set can be used so depending upon operator policy it may be that Authentication is not performed after the initial UE message.

To co-ordinate paging in the two CN domains (CS and PS) the CN informs the RNC of the permanent NAS UE Identity (the IMSI) once an Iu signalling connection is established using the CommonID message. The RNC associates the IMSI to the UE Specific Signalling Connection of that user and saves it for the duration of the UE Specific Signalling Connection. A typical (but not the only) stage where the CN may generate this message is following SecurityModeComplete, as shown.

Following this exchange, the MSC/VLR completes the IMSI Attach transaction by sending a LocationUpdateAccept to the UE containing a new NAS Temporary ID (TMSI). The UE acknowledges this with TMSIReallocationComplete. From now on the UE is camped on the network. Both the UE and CN maintain a mobility management context. This means that the UE responds to incoming paging messages from the CN and carry out Periodic Location Area Updates and be able to exchange SMS via the CS domain and receive CBC messages. The VLR continues to maintain a record of the Location Area of the Attached UE in order to page the UE for incoming traffic.

At the close of this transaction, the CN would typically withdraw the signalling connection using the IuReleaseCommand/IuReleaseComplete exchange, but both the UE and CN continue to maintain a mobility management context and re-establish the signalling connection as needed.

A.2.5.2 GPRS Attach Procedure

The GPRS Attach procedure (also refer to ETSI TS 124 008 [i.4], clause 4.7.3.1 and ETSI TS 123 060 [2], clause 6.5.2) is initiated by the UE to gain access to UMTS packet switched services. This procedure is also used to execute a combined IMSI/GPRS Attach for UEs supporting PS/CS operation if the network operates in Network Mode of Operation I, thus removing the need to carry out a separate GPRS Attach and IMSI Attach.

The Attach sequence for the PS domain, shown in Figure A.4, is similar to that described for the CS domain. The Initial Direct Transfer message contains instead a (GMM) AttachRequest message. The Attach Type information element within this message indicates to the SGSN whether a GPRS Attach or combined IMSI/GPRS Attach is required.

The authentication and security mode procedures take place as before.

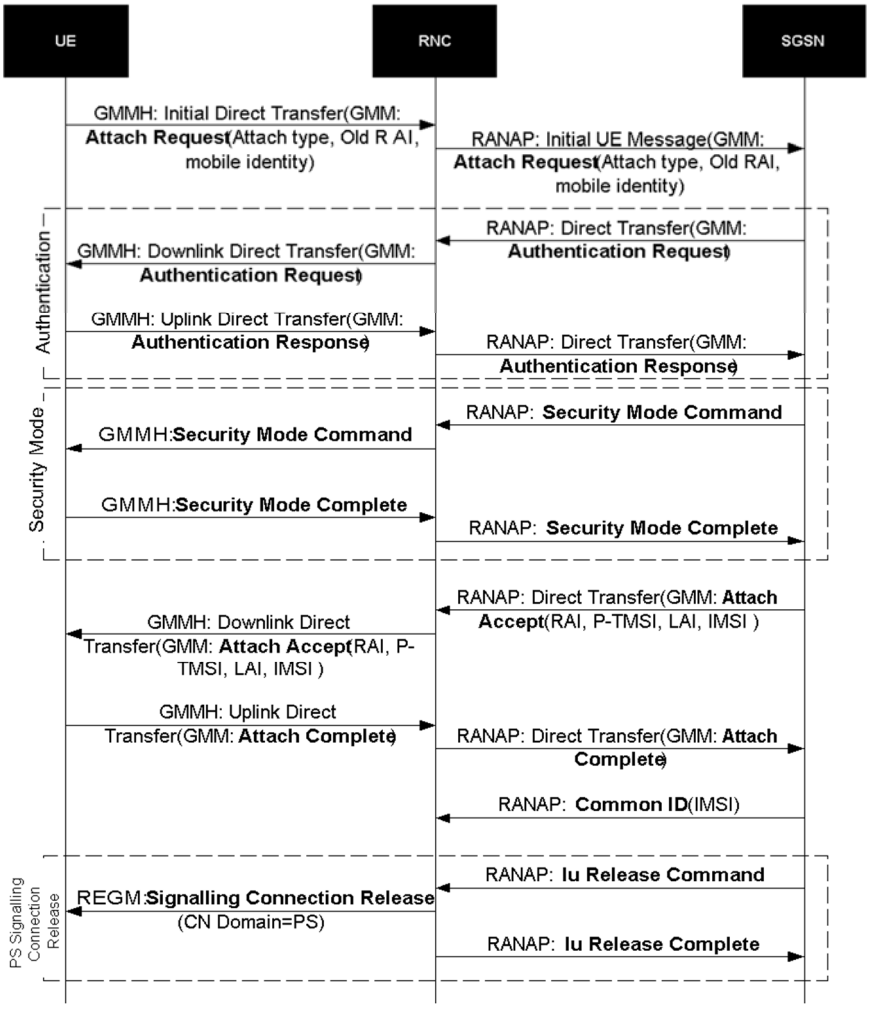

Figure A.4: GPRS Attach or Combined GPRS/IMSI Attach

A.2.6 Mobile Originated Circuit Switched Call Set Up

A mobile originated circuit switched call may be established when a user keys in the recipient's directory number and presses a "send" button on their handset. An Iu Signalling Connection to the CS domain of the Core Network is established to pass a Call Setup message to the MSC.

The message sequence exchanged across the satellite radio interface for a mobile initiated circuit switched call is presented in Figure A.5.

In this sequence it is assumed that the UE is already Attached to the CS CN domain (using the exchanges described previously) and that there is a UE-Specific Signalling Connection to the RNC but the signalling connection does not extend to the serving MSC/VLR. In order to pass a Call Setup message, the CS Signalling Connection to the MSC/VLR needs to be re-established.

The UE begins the procedure by sending a CMServiceRequest message indicating that a mobile originated (MO) call is to be established.

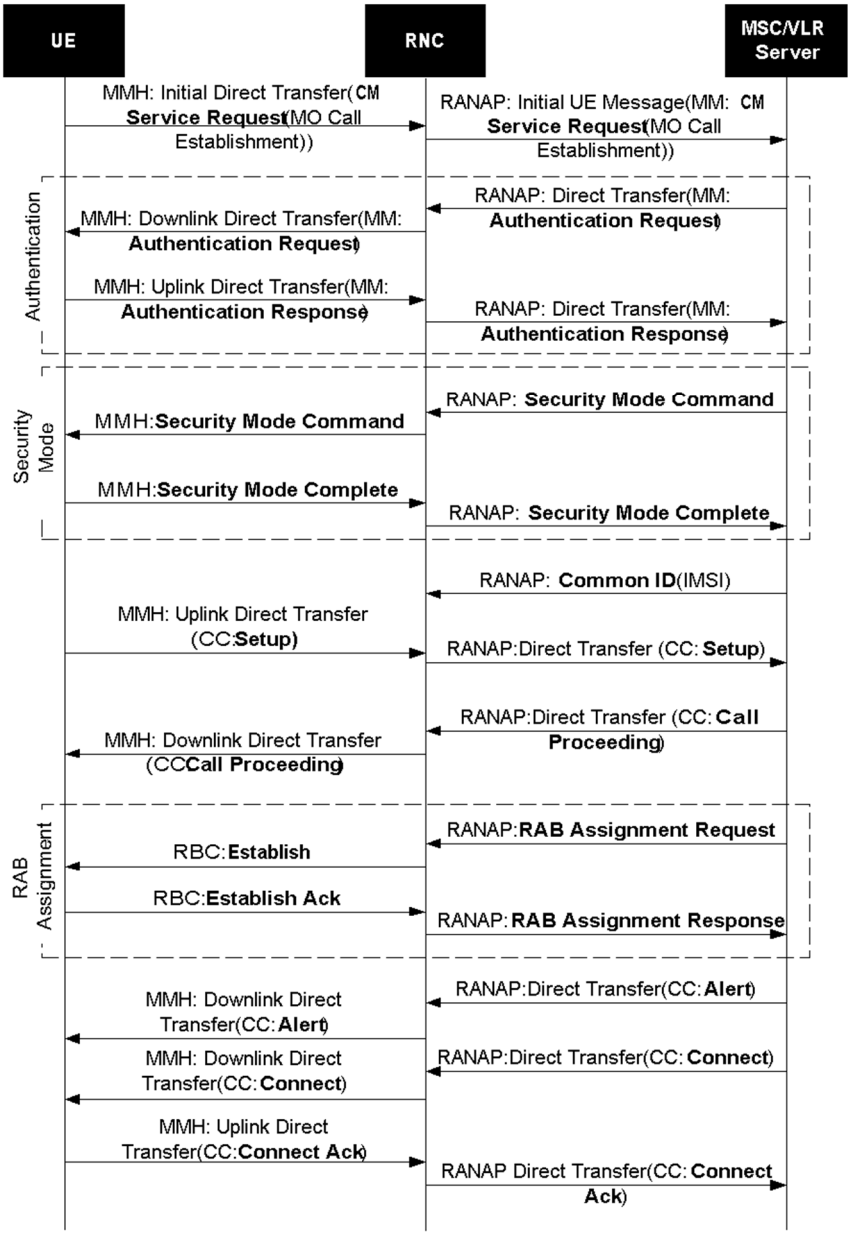

Figure A.5: Mobile Originated Circuit Switched Call

The MSC/VLR may respond by re-authenticating the UE and re-establishing security procedures, depending on operator configuration. The MSC/VLR undertakes the RANAP CommonID procedure once the Iu Signalling Connection is established to allow paging co-ordination between CN domains - for example the CommonID can be passed to the RNC after SecurityModeComplete.

The UE then sends the (CC) Setup message to the MSC/VLR. This message contains the destination directory number of the call and the type of service required (e.g. speech or circuit switched data) that was requested by the user.

The MSC/VLR responds to the Setup message with a CallProceeding message that indicates to the originating UE that the network has received the call information necessary to begin establishing the call.

At this stage the CN establish a bi-directional user plane traffic channel between the UE and CN using the RAB Assignment procedure.

The MSC/VLR passes an Alert message to the UE to indicate to the UE that user alerting has been initiated at the called address (i.e. the destination is alerted to the incoming call and the originator is made aware that the call has arrived but not been answered).

When the destination answers the incoming call, a Connect message is passed to the originating UE. The UE stops the alerting indication, passes back a ConnectAck message and connects the user and destination via the user plane connection. The call is now established and both parties can converse until one or other party clears the call.

A.2.7 Emergency Calls

The satellite network is required to support UMTS emergency speech calls (also refer to ETSI TS 122 101 [i.1], clause 9). An emergency call consists of a mobile originated CS call that is routed to the emergency services in accordance with national regulations of the country where the subscriber is located.

A typical scenario of the establishment of an emergency call is as a result of a user pressing a dedicated "emergency call" number on their handset or entering a well known emergency directory number (e.g. 911, 999, 112 etc.) that is recognized by the UE as an emergency number. The requirements describing emergency numbers to be supported by the UE are established in ETSI TS 122 101 [i.1], clause 9.1.

The satellite network uses the reported UE Service Area to route the call to the emergency call centre appropriate to the national regulations of the country in which the UE is located. The UE's Service Area Identifier is determined by the RNC on the basis of the UE's reported GPS co-ordinates.

An example message sequence for Emergency Call is shown in Figure A.6. The messages exchanged are similar to a conventional mobile originated CS call. The CMServiceRequest message indicates service type as "Emergency Call Establishment".

As a result of this service request, Selective Authentication and Security Mode procedures take place, as was the case for conventional MO CS calling. The network operator may optionally permit users to make emergency calls without a SIM/USIM, as illustrated in Figure A.7. In the absence of the SIM, Security Mode, Authentication and CommonID are not undertaken (because of the absence of IMSI/TMSI). The MSC/VLR instead responds with a CMServiceAccept message to indicate to the UE that the CS Signalling Connection is established.

The permission to make an emergency call without a SIM/USIM is a configuration setting in the Core Network. If the capability is not enabled the CN MSC responds with a CMServiceReject.

An additional mechanism is available for the network operator to prohibit/allow Emergency Calls without SIM/USIM. A broadcast Access Control System Information AVP is defined to flag to UEs whether Registration using IMEI is permitted and thus inhibit/allow emergency calls without SIM prior to the Registration stage. Following the establishment of the CS signalling connection, the UE generates the Call Control message EmergencySetup to the MSC/VLR. This message contains no calling or called party directory number, unlike the conventional (CC) Setup message. Instead the MSC/VLR takes charge of routing the emergency call to the appropriate national Public Service Access Point (PSAP).

At the operator's discretion, emergency call numbers other than those recognized by the UE may be recognized as requiring routing to national PSAPs. Such calls would be handled as conventional MO CS calls by the UE and CN.

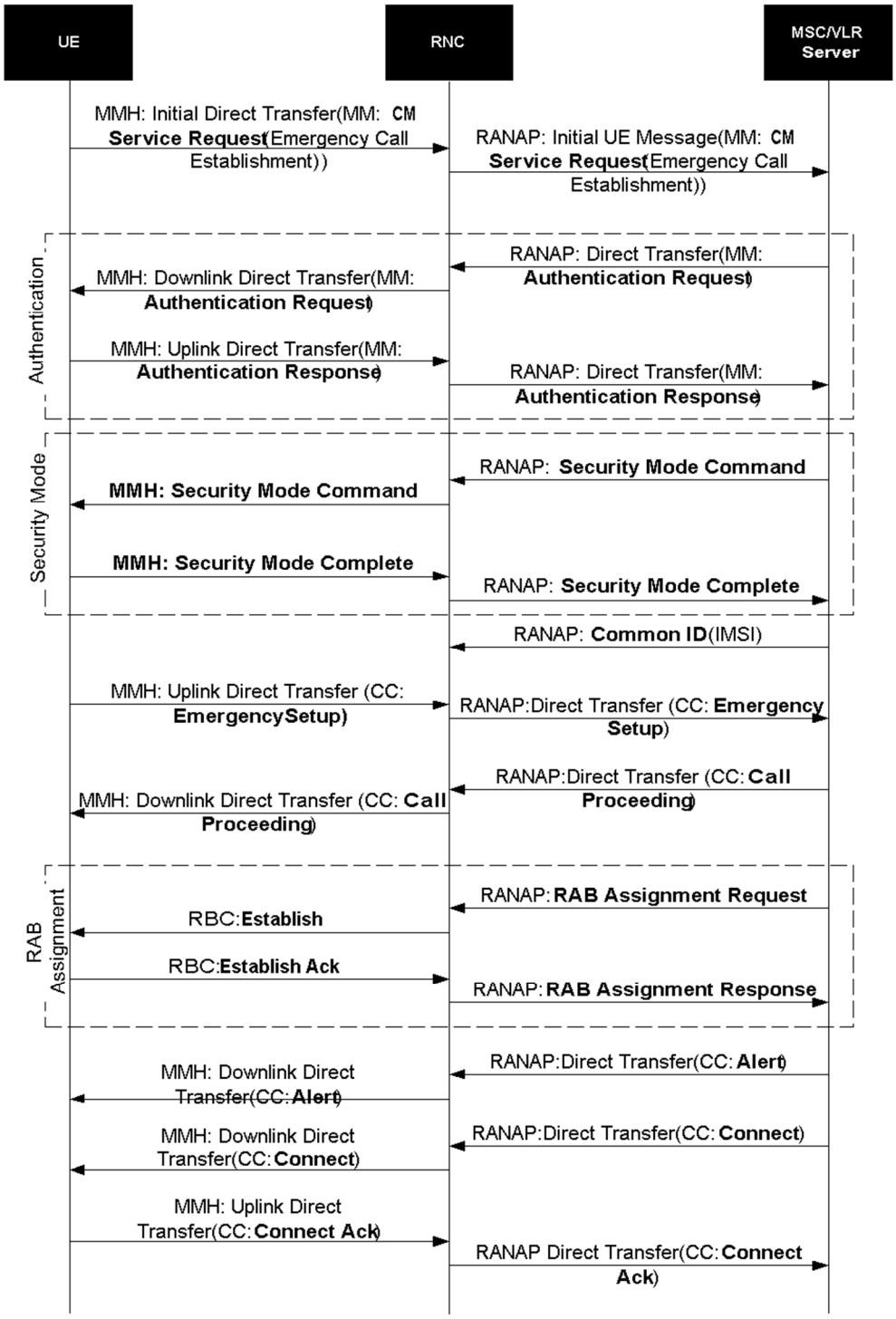

Figure A.6: Emergency Call - case 1
(UE is Registered prior to this procedure and has SIM/USIM)

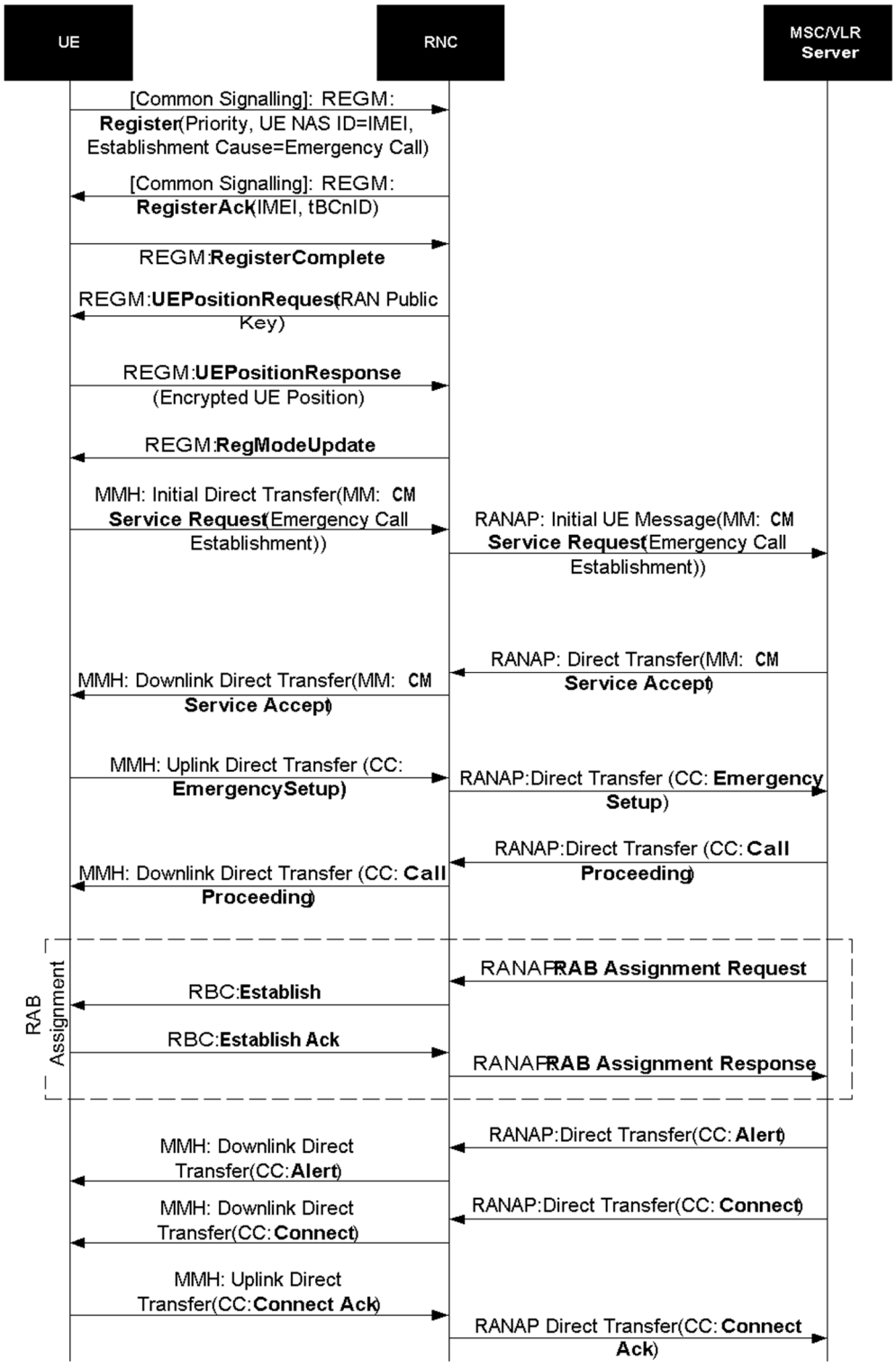

Figure A.7: Emergency Call - case 2
(UE without SIM/USIM)

A.2.8 Mobile Terminated Circuit Switched Call Set Up

In the case of a mobile terminated circuit switched call, the visited MSC/VLR receives the indication of an incoming call from an external network and alerts the UE to the incoming call.

In order for the incoming call to reach the UE, the Core Network needs to know the whereabouts (have a mobility management context) for the UE at least to the resolution of its Location Area. The CS Core Network therefore needs a record of the UE's location, i.e. the UE needs to be Attached to the CS domain prior to the incoming call signal.

A typical call flow for this scenario is shown in Figure A.8 and Figure A.10. Prior to this transaction, the UE has Attached but retains no CS Signalling Connection to the CS domain of the Core Network. In the absence of a CS signalling connection, the MSC/VLR needs first to page the UE to request that the UE sets up a signalling connection and only then can it pass the (CC) Setup message back to the UE.

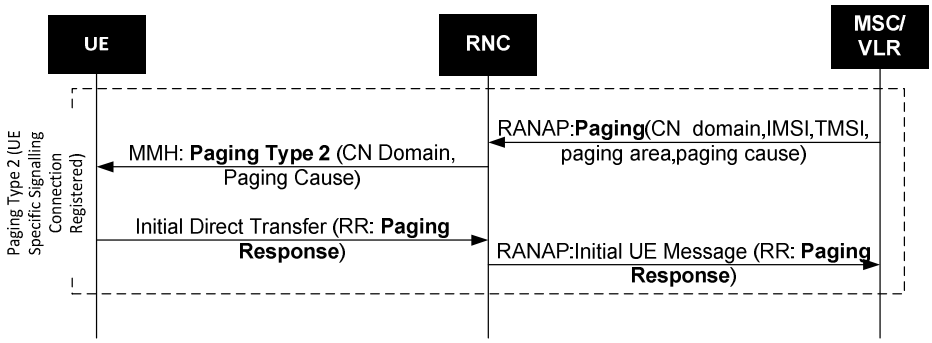

Figure A.8: Mobile Terminated CS Call Paging Type 2

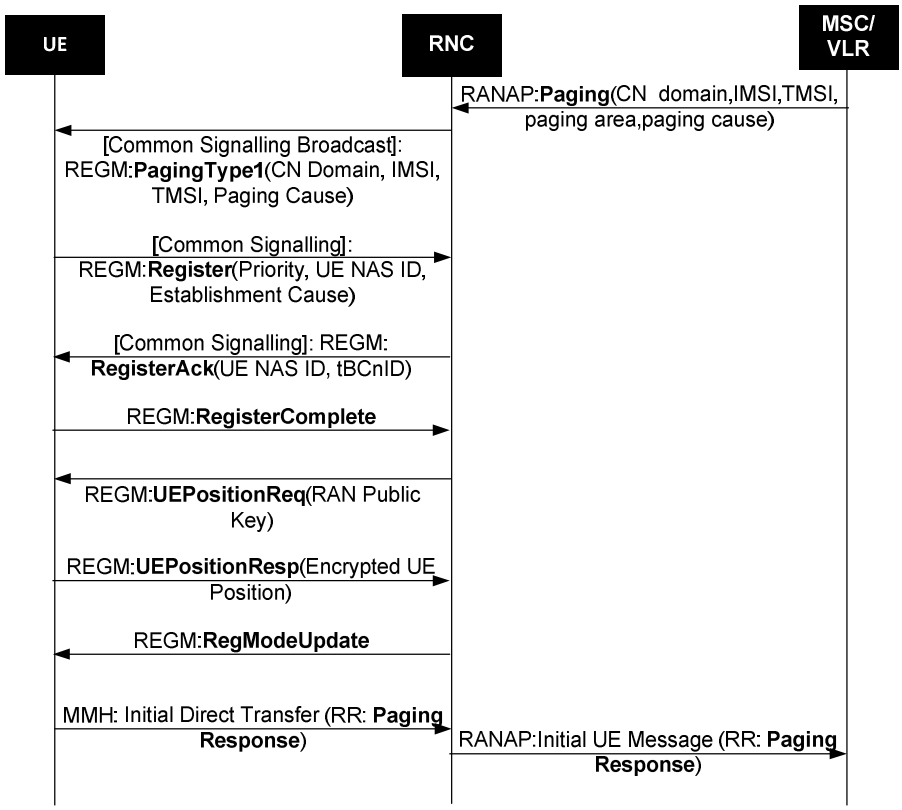

Figure A.9: Mobile Terminated CS Call Paging Type 1

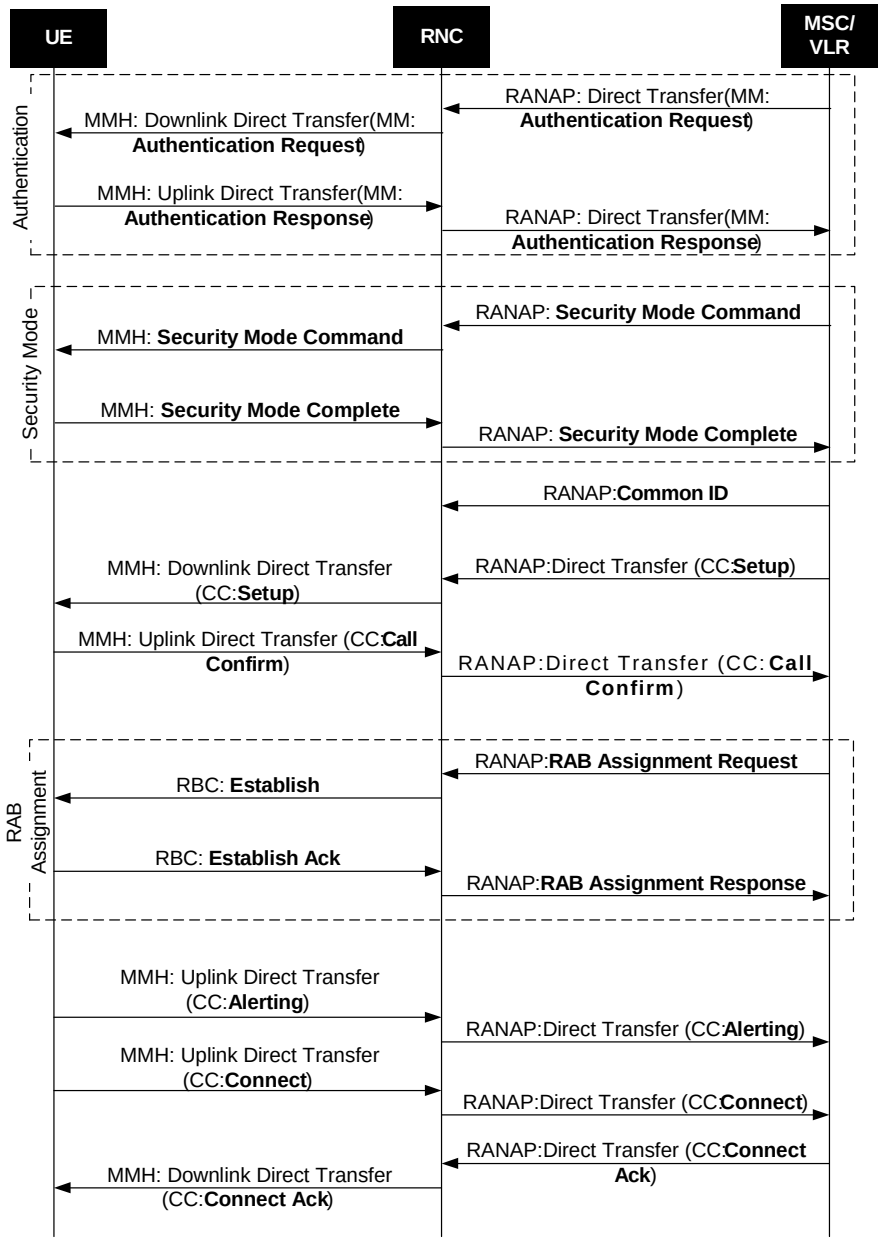

Figure A.10: Continuation of Mobile Terminated CS Call

The MSC/VLR sends a Paging message to the RNC or RNCs which control the Location Area (LA) that the UE is reported to be in according to its MM context. The RNC checks whether a UE Specific Signalling Connection is active for the IMSI/TMSI concerned and if so the RNC uses the UE Specific Signalling Connection to page the UE (Paging Type 2, illustrated in Figure A.8). The UE then returns a Paging Response.

In the case where a UE is both IMSI- and GPRS-Attached and the network is in NMO-I, the MSC/VLR executes paging for CS services via the SGSN. The procedure is otherwise the same: in both Paging and Paging Response messages, the CN Domain Indicator is set to "CS" as described in ETSI TS 123 060 [2], clause 6.3.4.

In the case that there is no UE Specific Signalling Connection for this IMSI/TMSI, the RNC needs to broadcast a paging message (Paging Type 1). To respond to the page, The UE needs to first establish a UE Specific Signalling Connection to the RNC before it can provide a Paging Response to the MSC/VLR, as illustrated in Figure A.9.

Note that the Paging Response message from the UE uses the "RR" Protocol discriminator for reasons of backwards compatibility as described in ETSI TS 124 008 [i.4], clause 4.5.1.3.3.

The Paging Response message is forwarded to the MSC/VLR using an Initial Direct Transfer message that establishes a dedicated signalling connection between the UE and the MSC/VLR.

The call flow following the Paging Response (illustrated in Figure A.10) is common to both Paging Type 1 and Paging Type 2 scenarios. The MSC/VLR may optionally carry out authentication and or security procedures at this point. Following this, the CN may pass a CommonID message to the RNC (CommonID provides the RNC with the UE's IMSI so that it may direct paging messages to the appropriate UE-Specific Signalling Connection when a NAS signalling connection exists for one domain but not the other).

The MSC/VLR then passes a (CC) Setup message to the UE, indicating to the UE that an incoming call exists. The UE check whether it can accept the call and if so, responds with a CallConfirm message.

The MSC/VLR then establishes a bi-directional user plane traffic channel between the UE and CN using the RAB Assignment procedure. The UE indicates to the MSC/VLR with the Alerting message that the user is being notified about the incoming call. The Connect message is sent by the destination UE when the user answers the call. The MSC/VLR responds with a ConnectAck when the originator completes the call and the user plane connection is established.

The circuit switched call now proceeds.

A.2.9 Circuit Switched Call Clearing

An established circuit switched call is cleared either by the UE or the MSC/VLR. The two sequences of messages are shown in Figure A.11 and Figure A.12.

In the case of a call cleared by the UE, the UE transmits an uplink (CC) Disconnect message towards the CN, which passes a message to the remote party. The response, Release, is passed back to the UE, which acknowledges this with a ReleaseComplete message. The MSC/VLR then instructs the RNC to withdraw the radio access bearer associated with the call and, in the absence of further transactions requiring a CS Signalling Connection, executes the CS Signalling Connection Release procedure.

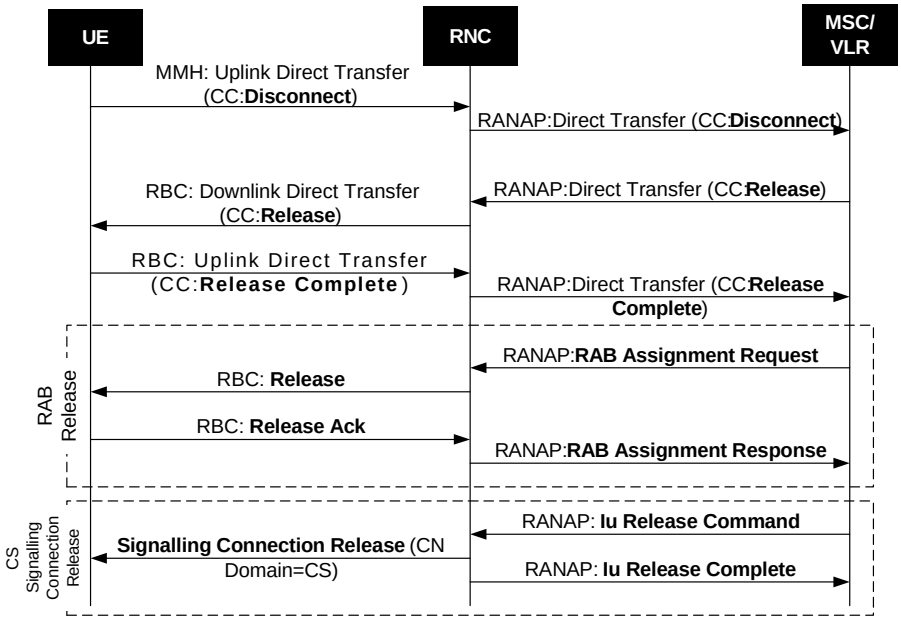

Figure A.11: Circuit Switched Call Clearing (Mobile Originated)

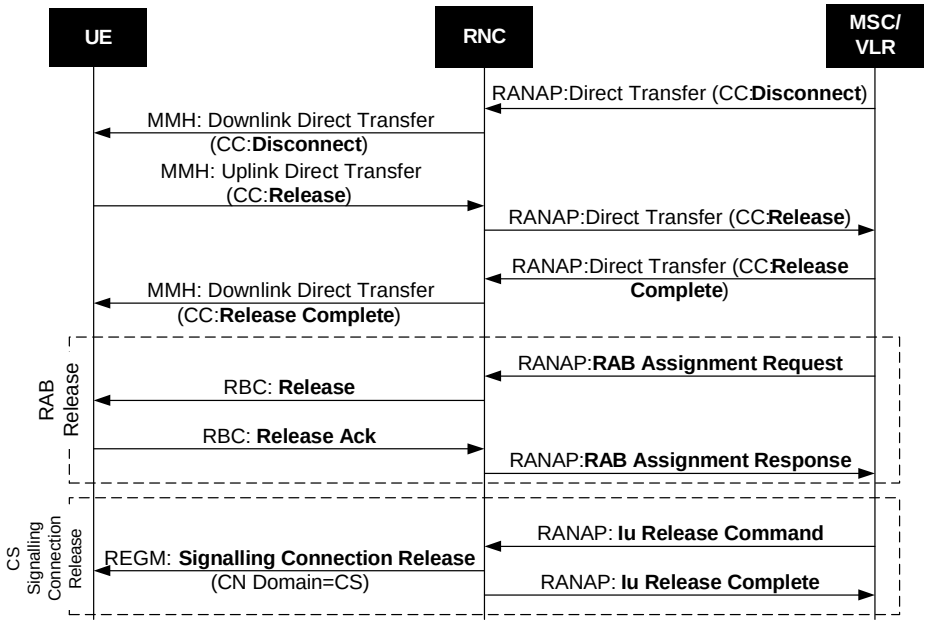

Figure A.12: Circuit Switched Call Clearing (Mobile Terminated)

In the case of a call cleared by the remote party, the MSC/VLR would forward a Disconnect Call Control message towards the UE. The UE would pass back a Release message in response, which would be acknowledged using a ReleaseComplete message. The MSC/VLR then instructs the RNC to withdraw the associated radio access bearer associated with the call.

At the completion of the call clearing transaction, the CN would typically release the signalling connection to the UE using the Iu Release procedure, i.e. the MSC/VLR may choose not to use a separate RAB release procedure but simply release the Iu connection once the call has ended.

A.2.10 Activation of Packet Switched Session, "PDP Context"

The PDP Context Activation procedure is used to assign a PDP address (i.e. an IP address) to a UE and to specify user plane capacity and Quality of Service for transferring PDUs associated with this address. The PDP Context Activation procedure also establishes a gateway (APN) via which the PDUs are routed. Packet switched session activation is assumed to be initiated by the UE. In response to the request from the UE, the PS CN establishes routing and encapsulation procedures to transfer uplink and downlink packets associated with this PDP context. It is possible for one or more simultaneous PDP contexts to be active to an individual UE depending on the UE capability (up to a maximum of 11).

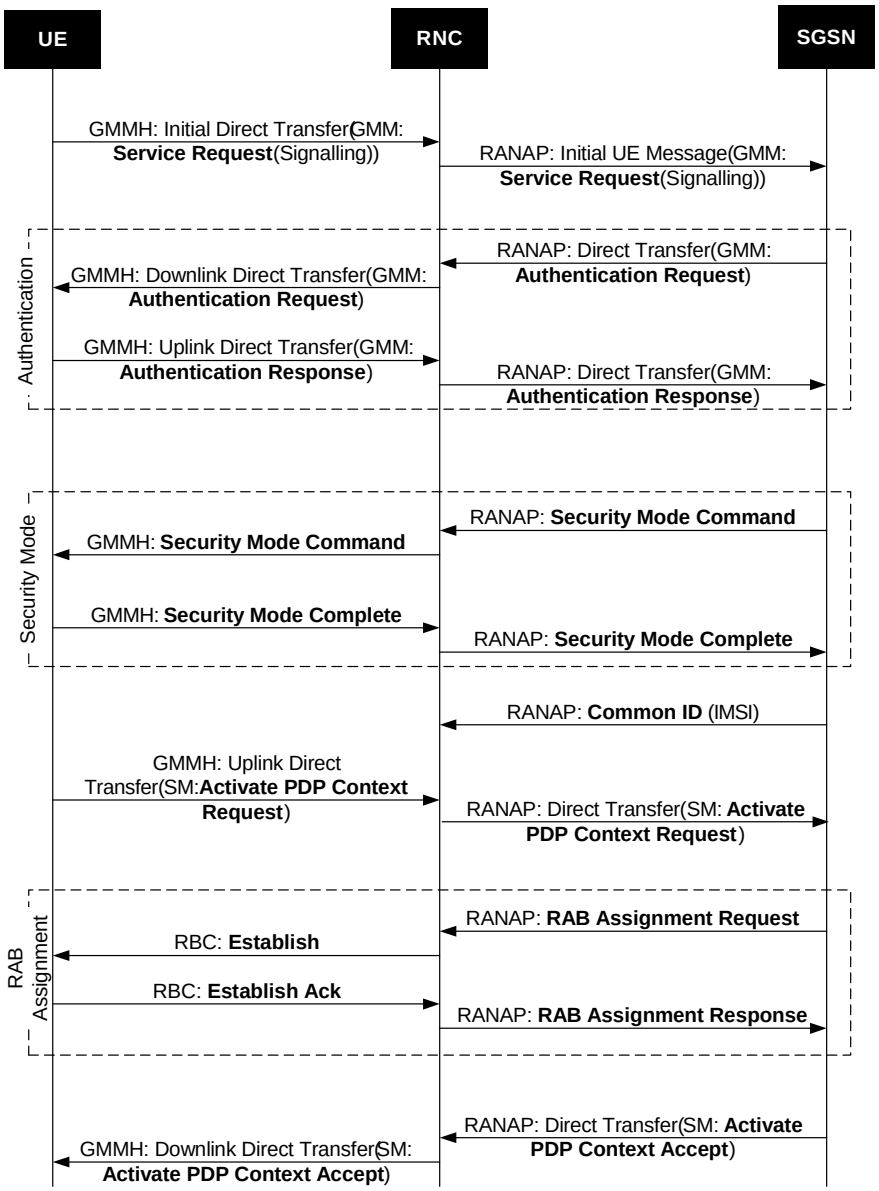

Figure A.13: Mobile Originated PDP Context Activation

The option of PDP context activation initiated by the CN is currently not supported in the satellite network. Only PDP context activation initiated by the UE is considered in the present document, as illustrated in Figure A.13.

Prior to requesting activation of a PDP context, the UE needs to have an established UE Specific Signalling connection to the RNC and then establish a PS signalling connection to the Serving GPRS Support Node (SGSN) for carrying subsequent Mobility Management and Session Management signalling to the CN PS domain. An Initial Direct Transfer message containing a ServiceRequest initiates the PS signalling connection. Note that if the UE already has a PS Signalling Connection (i.e. "PMM Connected" mode) then the UE initiates the PDP context directly with an UplinkDirectTransfer containing the SM:ActivatePDPContextRequest message.

On establishing a signalling connection to a UE, the SGSN may optionally initiate the authentication (depending on selective authentication settings) and undertakes security mode procedures. Note that there is no response to the GMM:Service Request message (see ETSI TS 124 008 [i.4], clause 4.7.13.3). Having established an Iu signalling connection the CN sends a CommonID message to the RNC containing the UE's IMSI to the RNC for the purposes of paging co-ordination between the CN domains.

On establishing the PS Signalling Connection the UE forwards the request to activate a PDP context over the established signalling connection to the SGSN. If accepted, the SGSN commands the RNC to establish the appropriate user plane radio interface capacity to support the PDP context using the RAB Assignment Request procedure. Successful establishment of user plane capacity is confirmed to the UE with the ActivatePDPContextAccept message from the SGSN to the UE. Exchange of packet data may now take place.

A.2.11 Deactivation of Packet Switched Session

PDP context deactivation is executed to remove the record of the PDP session from both the UE and the SGSN. Following this procedure no further packet traffic associated with this PDP context may be exchanged.

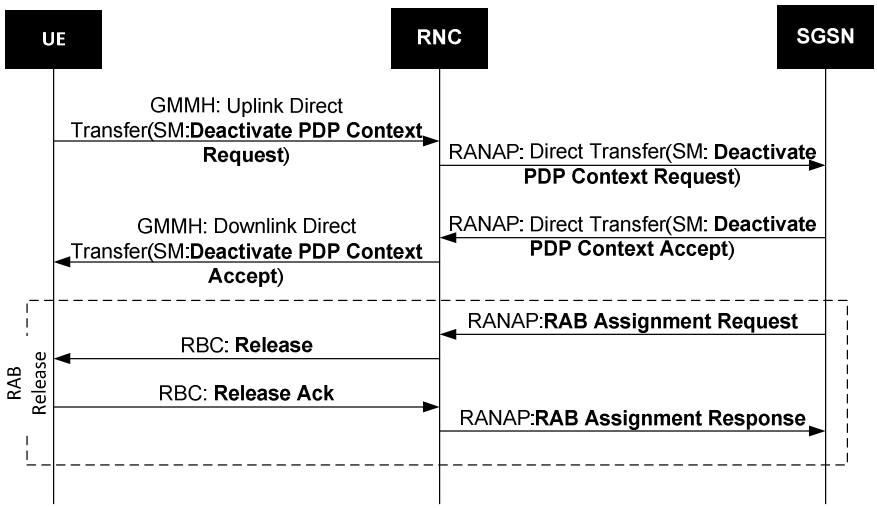

Figure A.14: PDP Context Deactivation (Mobile Initiated)

A previously established PDP context may be deactivated at the request of either the SGSN or the UE. An example of PDP Context Deactivation at the request of the UE is presented in Figure A.14. An example of a PDP Context Deactivation at the request of the CN is presented in Figure A.15.

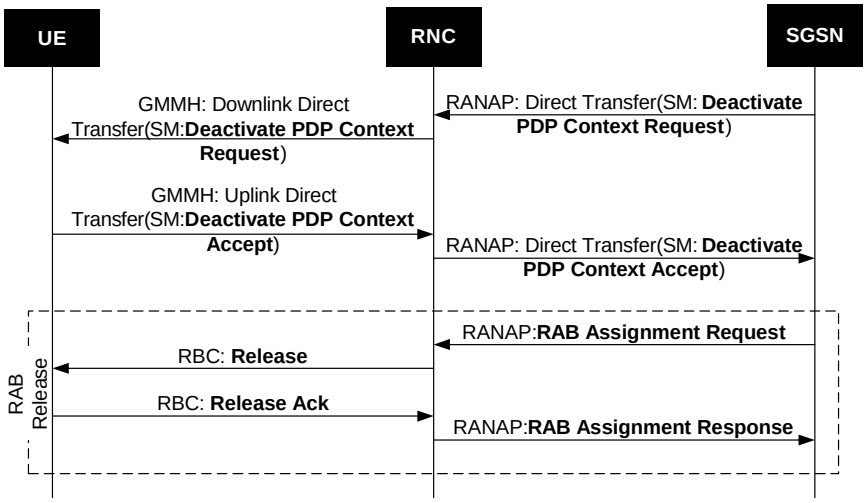

Figure A.15: PDP Context Deactivation (SGSN Initiated)

In the mobile initiated deactivation case, the UE passes the (SM) DeactivatePDPContextRequest message to the SGSN on the established PS signalling connection between the UE and SGSN. The SGSN accepts this message and responds with DeactivatePDPContextAccept to the UE. The SGSN then commands the RNC to withdraw the user plane capacity associated with this PDP context using the RABAssignmentRequest message.

In the SGSN initiated deactivation case, the SGSN originates the DeactivatePDPContextRequest message and this is responded to using DeactivatePDPContextAccept at the UE. Again, the SGSN commands the RNC to withdraw the user plane capacity.

Following successful execution of this transaction, uplink or downlink user plane PDUs associated with this PDP context is discarded.

In the absence of further transactions requiring a PS Signalling Connection to the UE, the SGSN releases the PS Signalling connection with a PS signalling connection release exchange with the RNC.

A.2.12 Preservation of PDP context during release of RAB/PS signalling connection

A.2.12.0 General

For further details also refer to ETSI TS 124 008 [i.4], clause 4.7.3 and ETSI TS 123 060 [2], clauses 9.2.5 and 6.12.1.

A.2.12.1 Temporary Release of a Packet Switched Radio Access Bearer due to Inactivity

A.2.12.1.0 General

The RNC may ask the SGSN to release the radio access bearer associated with a background or interactive class PDP context (e.g. as a result of inactivity on the RAB). This PDP context remains active (preserved) in the CN and UE for subsequent packet transfer but the user plane bearer has temporarily been withdrawn. RABs for other PDP contexts may remain and the PS signalling connection remains active. The sequence of messages exchanged is shown in Figure A.16. Note that a configurable inactivity timer governs RNC request for temporary release of PS RABs. The inactivity timer is configured by the network operator.

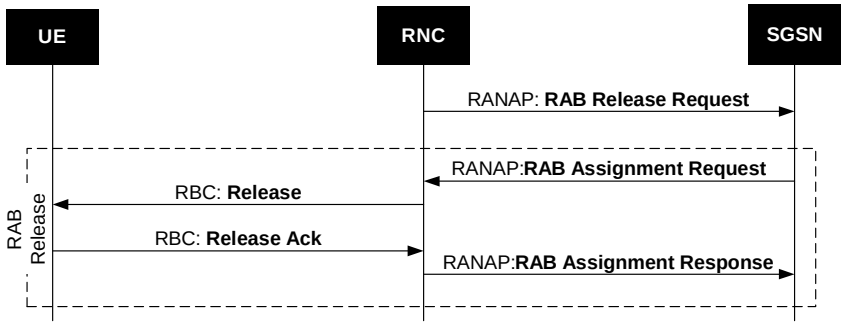

Figure A.16: Temporary RAB release due to inactivity

A.2.12.1.1 Uplink PDU causing restoration of packet switched RAB following Earlier release

A new RAB is assigned for this PDP context in the event of subsequent user plane activity, e.g. the arrival of uplink PDUs at the UE.

The sequence of messages resulting from the arrival of a PDU at the UE for transmission in the uplink/return direction is illustrated in Figure A.17. The UE indicates to the SGSN that a RAB needs to be assigned due to data waiting to be transmitted with the (GMM) ServiceRequest(Data) message.

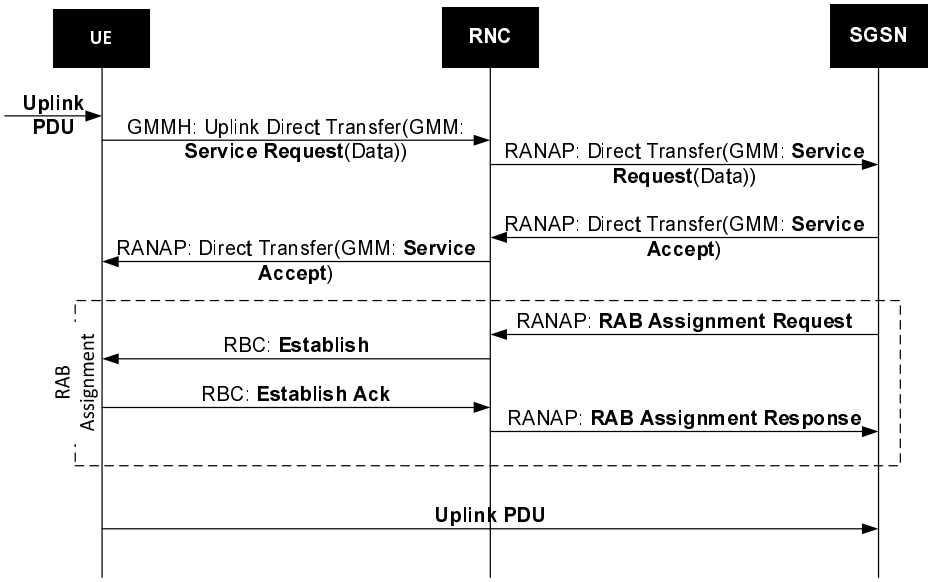

Figure A.17: Resource reservation for active PDP context in PMM-connected mode where RABs were previously released (e.g. due to inactivity) and user plane capacity is required due to uplink PDU

The SGSN indicates to the UE that it is resuming the pending user plane service with the ServiceAccept response. The SGSN then re-establishes RABs for all active PDP contexts that are without user plane bearers for this UE.

A.2.12.1.2 Downlink PDU causing restoration of Packet Switched RAB following earlier RAB release

The sequence of messages resulting from the arrival of a PDU at the SGSN for transmission in the downlink direction is illustrated in Figure A.18. At the arrival of the PDU, the SGSN recognizes the absence of a RAB for the associated PDP context and initiates a RANAP RAB Assignment procedure towards the RNC via the PS domain Iu Signalling Connection associated with this UE. Note that the SGSN re-establishes RABs for all active PDP contexts for this UE that are without user plane bearers.

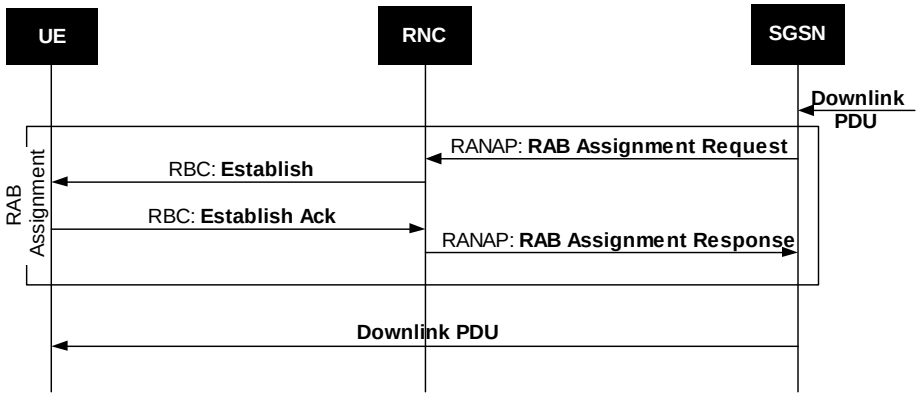

Figure A.18: Resource reservation for active PDP context in PMM-connected mode where RABs were previously released (e.g. due to inactivity) and user plane capacity is required due to downlink PDU

A.2.12.2 Temporary Release of a Packet Switched Signalling Connection due to Inactivity

A.2.12.2.0 General

The RNC may request the release of the UE's PS Signalling Connection to the SGSN while PDP contexts are active (for example due to user inactivity), as shown in Figure A.19. In releasing the PS Signalling Connection, all PS RABs for that UE are released.

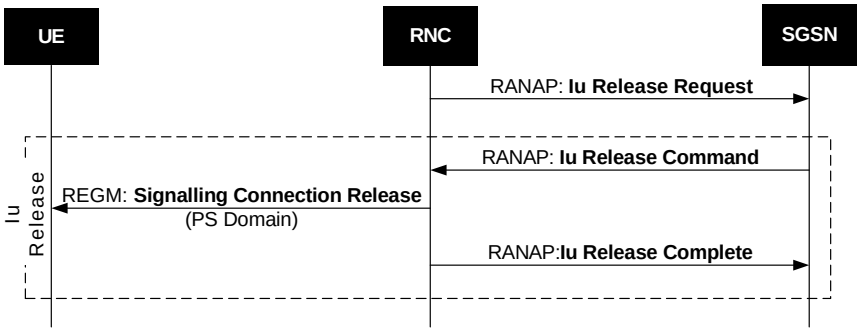

Figure A.19: Release of PS Signalling Connection and associated RABs triggered by RNC due to Inactivity

The PDP contexts can remain active even without either user plane bearers or PS Signalling Connection. The subsequent arrival of a PDU at either the UE or SGSN triggers the re-establishment of both a PS Signalling Connection and user plane bearers.

A.2.12.2.1 Uplink PDU arrival causing restoration of PS Signalling connection and RABs following Earlier release

The subsequent arrival of a PDU at the UE for transmission in the uplink direction is illustrated in Figure A.20. If no UE Specific Signalling Connection is outstanding between the UE and RNC then this needs to be established using the Register procedure. With a UE Specific Signalling Connection the UE initiates a PS Signalling Connection to the SGSN using the InitialDirectTransfer message to pass a ServiceRequest(Data) message to the SGSN.

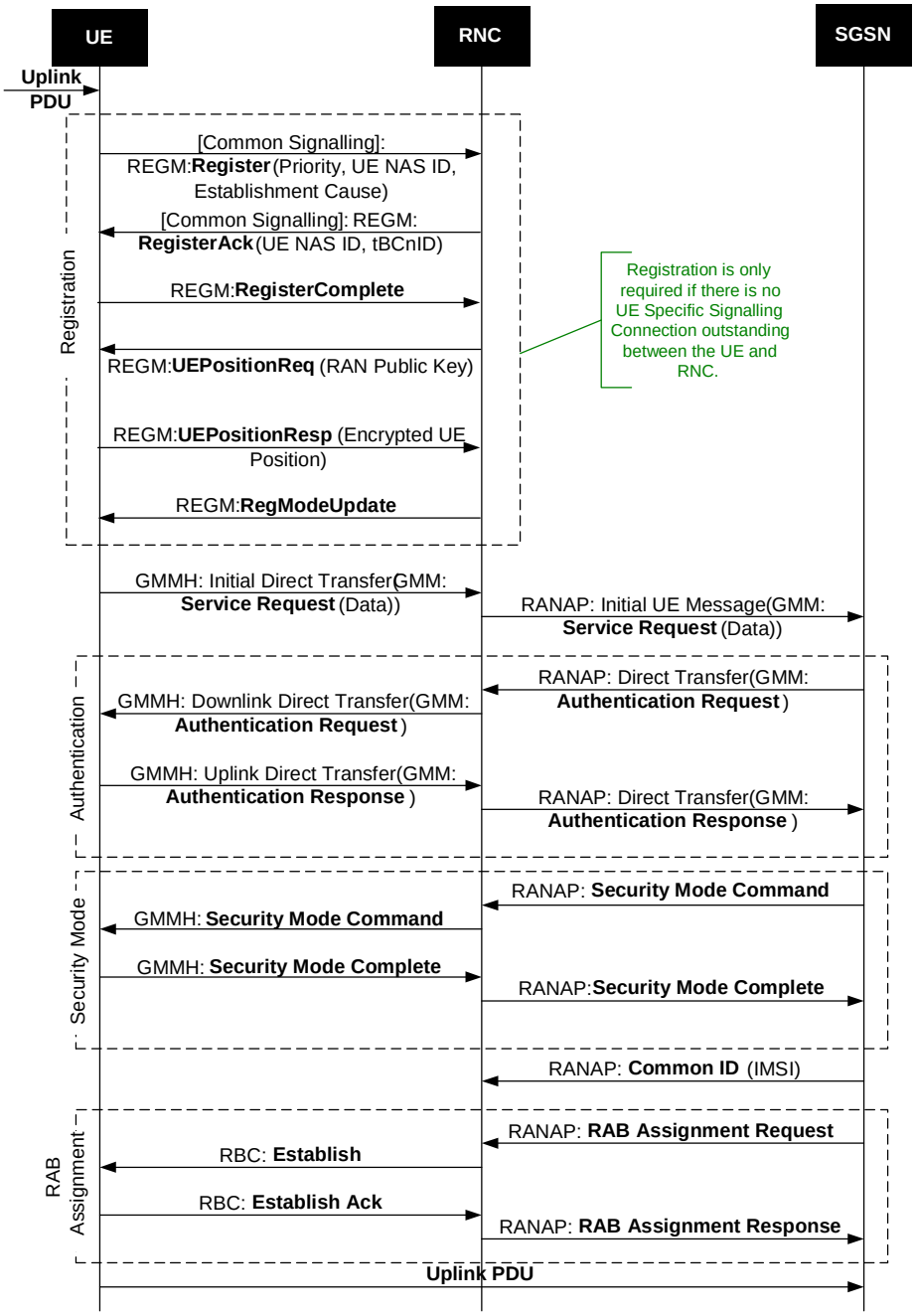

Figure A.20: Resource reservation due to arrival of uplink PDU for active PDP context in PMM-idle mode where RABs and PS signalling connection were previously released (e.g. due to inactivity)

Initiation of a PS Signalling Connection to the SGSN may trigger the Authentication procedure (depending on Selective Authentication settings) and the Security Mode procedure, as shown. No ServiceAccept message is generated because the Security Mode Procedure implicitly acknowledges the ServiceRequest from the UE. The service type of "Data" in the ServiceRequest message indicates to the SGSN to initiate RAB assignments for all active PDP contexts for the UE, thus allowing the PDU transmission to proceed.

A.2.12.2.2 Downlink PDU arrival causing restoration of Iu PS Signalling connection and RABs following Earlier release

PDUs may arrive at the SGSN destined for a UE that no longer has a PS Signalling Connection but has active PDP context(s) (the PS signalling having been withdrawn, as described in clause A.2.12.1). To restore the transmission of PDUs, the UE needs to be paged by the SGSN to trigger the UE to request a PS Signalling Connection and allow the SGSN to establish RABs. This case is illustrated in Figure A.21.

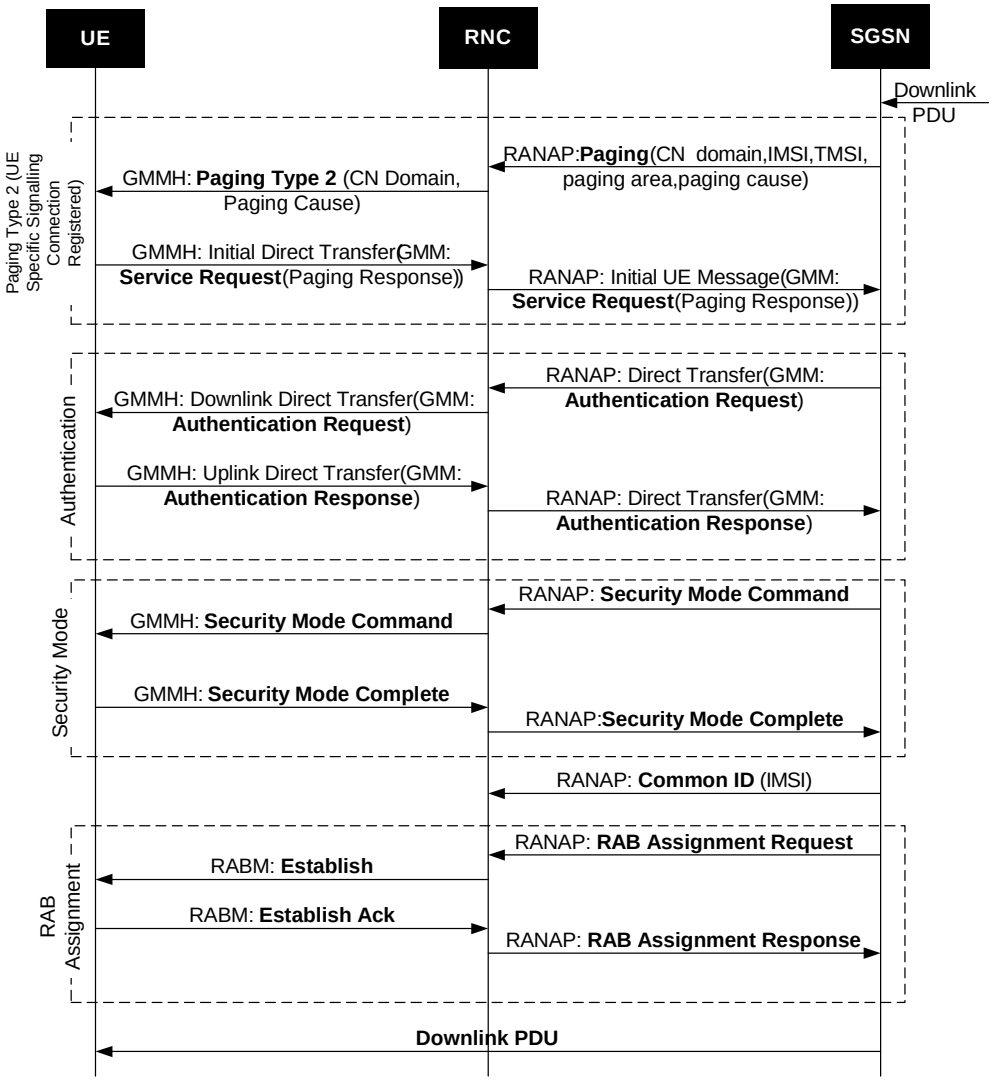

Figure A.21: Resource reservation due to arrival of downlink PDU for active PDP context in PMM-idle mode where RABs and PS signalling connection were previously released (e.g. due to inactivity) and UE Specific Signalling Connection is Active

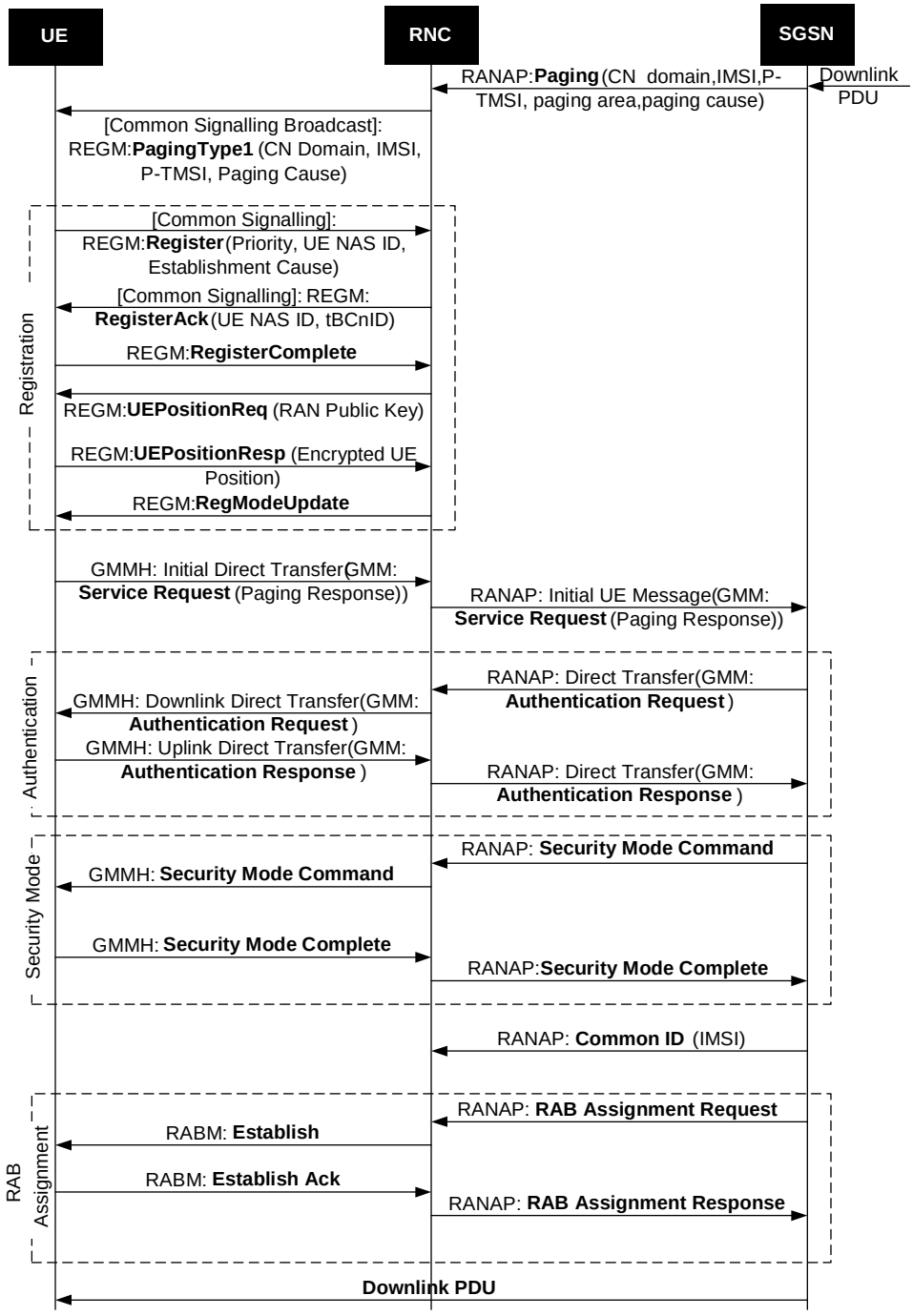

Figure A.22: Resource reservation due to arrival of downlink PDU for active PDP context in PMM-idle mode where RABs and PS signalling connection were previously released (e.g. due to inactivity) and no UE Specific Signalling Connection is Active

The arrival of the downlink PDU at the SGSN triggers the SGSN to generate a (RANAP) Paging message towards all RNCs associated with the Routing Area that the UE last reported.

The RNC may have a UE-Specific Signalling Connection to the UE and forward the Paging request to the UE on this connection (paging type 2, as illustrated in Figure A.21). Were the UE to have no UE-Specific Signalling Connection then the RNC would broadcast a Paging message for the UE (Paging Type 1) to force a re-establishment of the UE-Specific Signalling Connection as shown in Figure A.22.

The UE responds to the Paging message by generating an InitialDirectTransfer message to set up a PS signalling connection to the SGSN and pass a (GMM) ServiceRequest(Paging) message.

Selective Authentication takes place followed by Security Mode procedures as shown. The execution of Security Mode procedures acknowledges the ServiceRequest to the UE and triggers the SGSN to assign RABs for all active PDP contexts associated with the UE. PDU transmission may then follow.

A.2.13 PS and CS detach

A.2.13.1 CS Detach, Mobile Originated

IMSI Detach (also refer to ETSI TS 124 008 [i.4], clause 4.3.4) deletes the circuit switched Mobility Management context for the UE/IMSI. Following IMSI Detach, external callers cannot reach the UE for CS calls. IMSI Detach puts the UE and MSC/VLR into MM-detached mode, in which the CS Core Network is no longer aware of the UE and the UE no longer sends any signalling messages to the MSC/VLR. IMSI Detach does not affect the PS domain.

An example of IMSI detach is initiated by the UE is illustrated in Figure A.23.

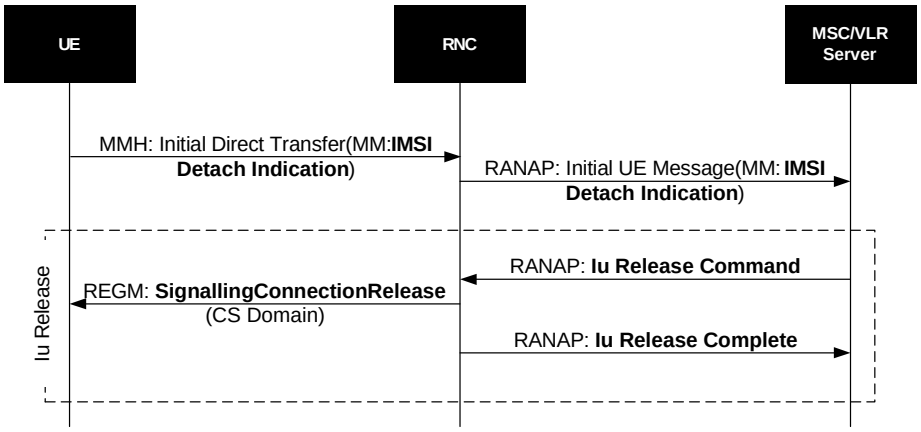

Figure A.23: IMSI Detach

The IMSI Detach procedure may be invoked if the UE is deactivated or the SIM is detached from the UE. The necessity or otherwise of UE carrying out the IMSI Detach procedure is broadcast in the network system information (if IMSI Detach is not required, the CN may implicitly detach the UE following timer expiry).

The UE announces that it is to be detached by sending an (MM) IMSIDetachIndication message to the MSC/VLR. The message is not acknowledged. After reception of the IMSIDetachIndication message, the MSC/VLR releases locally any ongoing Circuit Switched Mobility Management connection for this UE by issuing an IuReleaseCommand to the RNC.

There is no equivalent IMSI detach initiated by the CN, the CN instead releases the UE's MM context locally if required to detach the UE in the CS domain.

A.2.13.2 Mobile Initiated Detach via the PS Domain (GPRS Detach, IMSI Detach or combined GPRS/IMSI Detach)

In this procedure the UE informs the PS domain of the CN that it no longer wants access to UMTS packet switched services (also refer to ETSI TS 124 008 [i.4], clause 4.7.3.1 and ETSI TS 123 060 [2], clause 6.5.2). If the UE is GPRS Attached and the network supports combined procedures then the same procedure towards the SGSN can also execute the CS domain (IMSI) Detach or combined GPRS/IMSI Detach, depending on the "Detach Type" indicated by the UE.

The GPRS Detach procedure puts the UE and SGSN into PMM-Detached state, in which the PS network is no longer aware of the UE and the UE no longer sends any periodic messages to the SGSN. The IMSI Detach procedure puts the UE and MSC/VLR into CMM-Detached state, by which the CS network is no longer aware of the UE and the UE no longer sends any periodic messages to the MSC/VLR.

The procedure is initiated by the UE passing a (GMM) DetachRequest message to the SGSN. The "Detach Type" indicated in this message selects whether a GPRS Detach, IMSI Detach or combined GPRS/IMSI Detach are required. The message also flags whether this message was initiated by the UE as a result of powering down the UE, i.e. "Power Switched Off" or a "Normal Detach".

If accepted, the user plane connections and NAS-signalling connection are deleted for the detached domain.

If "Normal Detach" was requested then a DetachAccept response is returned by the SGSN to the UE to complete the procedure as illustrated in the example Figure A.24. If "Power Switched Off" was indicated then no DetachAccept response is returned, as illustrated in Figure A.25.

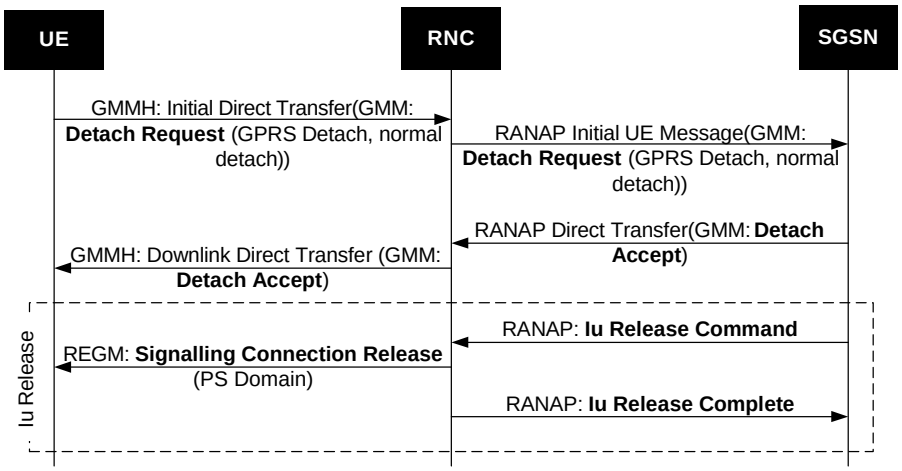

Figure A.24: UE Initiated GPRS Detach (Normal Detach Case)

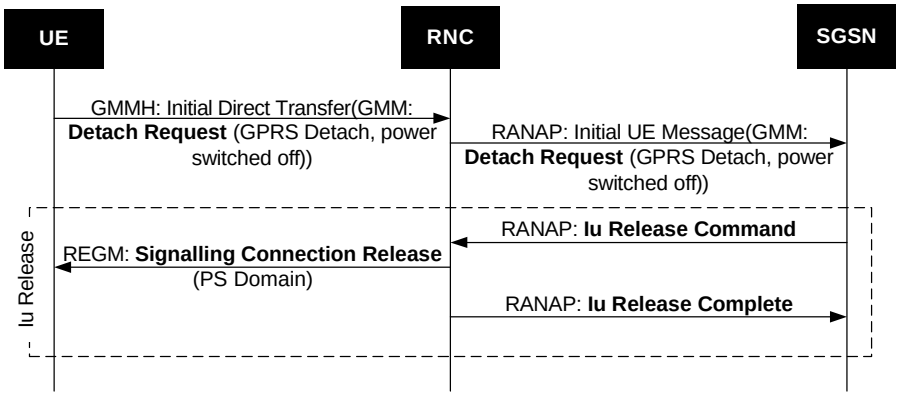

Figure A.25: UE Initiated GPRS detach (Power Switched off Case)

An example of combined GPRS/IMSI Detach is illustrated in Figure A.26.

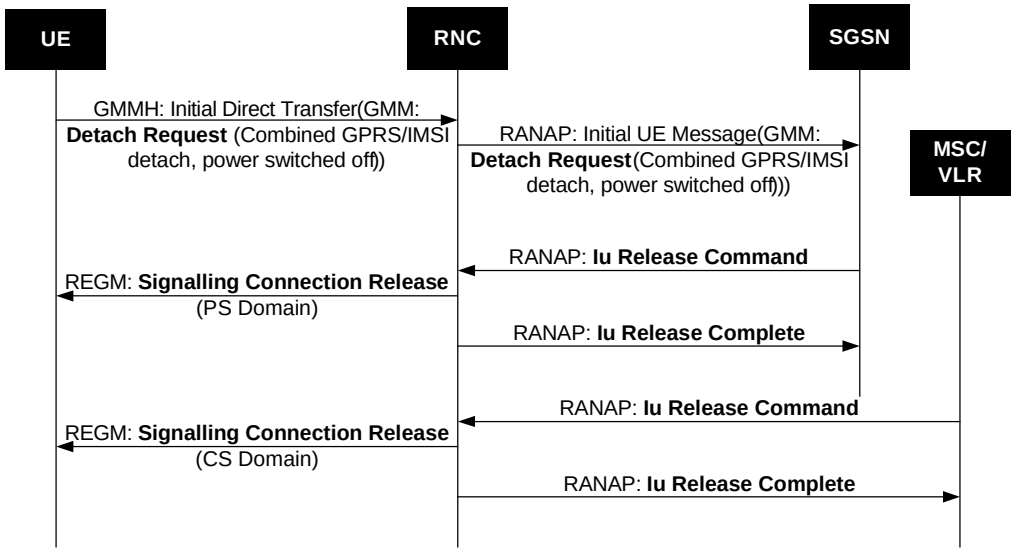

Figure A.26: UE Initiated combined GPRS/IMSI Detach

A.2.14 Handover

A.2.14.0 General

The above examples mainly consider the Non Access Stratum procedures related to the provision of various services. In the Access Stratum, radio bearers need to be managed efficiently and a Radio Access Bearer Setup or Release may lead to the UE being moved from one beam to another. Furthermore future versions of UEs (i.e. maritime and in particular aeronautical versions) may require being moved from one beam to another due to a change in their location.

A.2.14.1 Radio Access Bearer Set-up and Release

Once a Radio Access Bearer set-up is initiated by the Core Network through the RANAP protocol, the RNC Radio Resource Management (RRM) determines whether the requested QoS can be provided on the Primary Shared Access Bearer, another Shared Access Bearer in the Regional Beam or a Shared Access Bearer in a Narrow Beam. It needs to take into account any RABs already in existence between the UE and the CN.

If required, the RNC may move the UE-Specific Signalling Connection together with all existing RABs for a UE to the new Shared Access Bearer. The new Shared Access Bearer may be transmitted in the same or a different beam which can serve the UE. A handover procedure within the RNC would only be invoked if the UE is being moved from one Bearer Control process to another (which is always the case if the UE is moved from one beam to another). A handover within the same RNC would not involve the Core Network, other than that a Location Area (or Routing Area) Update would occur at the conclusion of the procedure.

The Handover procedure is described in detail in ETSI TS 102 744-3-6 [i.15] and ETSI TS 102 744-3-2 [i.13]. In summary, the handover process is triggered by a RRM event in the Bearer Control Layer, such as the decision of the RNC host to move Radio Access Bearers from a regional beam (the "source") to a narrow spot beam (the "target"). The Bearer Control Layer then configures the target Bearer Control process but leaves connections to the source Bearer Control process intact. The Bearer Control Layer next informs the Adaptation Layer (via the Bearer Connection Layer) of the handover. In response, the Adaptation layer sends a Handover message over the existing UE-Specific Signalling Connection (via the source Bearer Control process).

The Adaptation Layer in the UE receives the Handover message and notifies the Bearer Control Layer. The Bearer Control Layer then reconfigures the Bearer Control process to communicate with the target Bearer Control process at the RNC. Next, the Bearer Control Layer informs the Adaptation Layer that the reattachment to the new Bearer Control process is complete. In response the Adaptation Layer sends a HandoverAck message to the RNC over the new UE-Specific Signalling connection (to the target Bearer Control process). The RNC Adaptation Layer then notifies the Bearer Control Layer that the HandoverAck message has been received. The Bearer Control Layer then causes the source Bearer Control process to detach from the old connections. The exchange of messages between UE and RNC is illustrated in Figure A.27.

In the meantime the UE has been tuned to the new frequency and has received the System Info provided to the UE by the RNC on the UE Specific Signalling Connection. The Non-Access Stratum functions in the UE detects a change in System Information (in particular a change in Location Area (and Routing Area) and performs the LA/RA Update procedure with the Core Network.

On release of a RAB the RNC may decide either to retain the UE on the same Shared Access Bearer (e.g. if another RAB is still in existence between the UE and the CN or if the Shared Access Bearer needs to be retained for RABs in use by other UEs) or to move the UE to a different Shared Access Bearer (e.g. back to the Regional Beam) and possibly discontinue the illumination of a particular Narrow Beam. Again, this is a decision for the Radio Resource Management process and the involvement of the Core Network is as above.

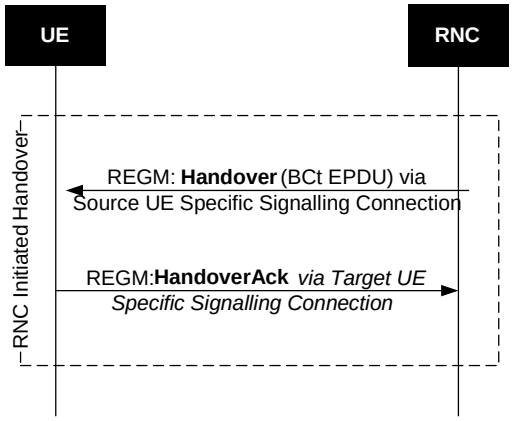

Figure A.27: RNC Initiated Handover of a UE between Bearer Control Processes

A.2.14.2 Change in UE Location

In addition to handovers that result from RRM decisions at the RNC, a handover may also be required because the UE is moving outside the coverage of one beam and into the coverage of another. Three different scenarios need to be considered:

1) The UE moves from one beam to another beam both on the same satellite and controlled by the same RNC ("intra-RNC")

2) The UE moves from one beam to another beam both on the same satellite but controlled by different RNCs ("inter-RNC")

3) The UE moves from one beam on one satellite to another beam on another satellite where these beams are controlled by different RNCs

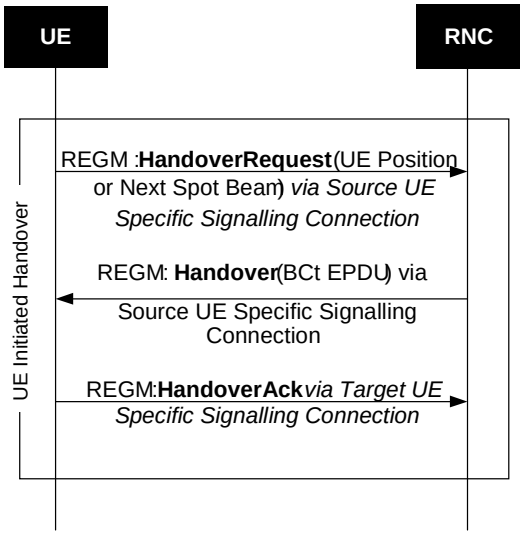

Figure A.28: UE Initiated Handover between Bearer Control Processes

A.2.15 Deregistration

The Deregistration procedure may take place if all Iu signalling connections (see ETSI TS 102 744-3-7 [i.16], clause 5) for a specific UE have been released. The Deregistration occurs just after the release of the last Iu signalling connection, or after a timer (UE Inactivity Timer) has expired; this is dependent on the RAN configuration. The deregistration procedure is described in clause 5.1.2 of ETSI TS 102 744-3-8 [i.17].

A.2.16 MBMS Context Activation

Multimedia Broadcast Multicast Services (MBMS), defined in the Authorization entity and referenced by a TMGI, are delivered to UEs using Multicast Radio Access Bearers established during an MBMS Context activation procedure.

Whenever it is necessary to deliver an MBMS Service to a UE, the MBMS Context Activation procedure will be initiated at the UE, either by an external trigger or by a Request from the BMSN. In the former case, it is required that the external control entity has a-priori knowledge of the MBMS Service identifier (TMGI) as it has to be present in the request (AT Command). The MBMS Context Activation procedure is described in clause 5.1.5 of ETSI TS 102 744-3-8 [i.17].

A.2.17 MBMS Context Deactivation

The MBMS Context Deactivation is a normal procedure when a UE no longer requests access to a specific MBMS Service. The MBMS Context deactivation is either initiated by the UE (for example after reception of an external AT command) or the Core Network (following reception of an IP Multicast Internet Group Management Protocol (IGMP) or PIM-SM "leave" message from the UE via the PDP Context). The MBMS Context Deactivation procedure is described in clause 5.1.6 of ETSI TS 102 744-3-8 [i.17].

Following the MBMS Context Deactivation procedure, the Core Network may release the MBMS Context if the UE was the last one associated to it (see clause 5.2.6 in ETSI TS 102 744-3-8 [i.17]).

History

Document history		
V1.1.1	October 2015	Publication