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**Digital cellular telecommunications system (Phase 2+) (GSM);
Functional stage 2 description of Location Services (LCS)
in GERAN
(3GPP TS 43.059 version 17.0.0 Release 17)**



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Foreword

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1 Scope

The present document specifies the stage 2 of the LoCation Services (LCS) feature in GERAN, which provides the mechanisms to support mobile location services for operators, subscribers and third party service providers.

The purpose of this stage 2 specification is to define the GERAN LCS architecture, functional entities and operations to support location methods. This description is confined to the aspects of LCS within the GERAN and does not define nor describe the LCS entities or operations within the Core Network.

Location Services may be considered as a network provided enabling technology consisting of standardised service capabilities, which enable the provision of location applications. The application(s) may be service provider specific. The description of the numerous and varied possible location applications which are enabled by this technology are outside the scope of the present document. However, clarifying examples of how the functionality being described may be used to provide specific location services may be included.

This stage 2 specification covers the GERAN LCS functional model and entities, the location methods, state descriptions, and message flows.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 22.071: "Location Services (LCS); Service description - Stage 1".
- [3] 3GPP TS 22.101: "Service aspects; Service principles".
- [4] 3GPP TS 23.007: "Restoration procedures".
- [5] 3GPP TS 23.032: "Universal Geographical Area Description (GAD)".
- [6] 3GPP TS 23.041: "Technical realization of Cell Broadcast Service (CBS)".
- [7] 3GPP TS 23.271: "Functional stage 2 description of location services".
- [8] 3GPP TS 24.008: "Mobile Radio Interface Layer 3 specification; Core Network Protocols; Stage 3".
- [9] 3GPP TS 24.030: "Location Services (LCS); Supplementary service operations; Stage 3".
- [10] 3GPP TS 24.080: "Mobile radio Layer 3 Supplementary Services specification; Formats and coding".
- [11] 3GPP TS 43.051: "GSM/EDGE Radio Access Network (GERAN) overall description; Stage 2".
- [12] 3GPP TS 44.006: "Mobile Station - Base Station System (MS - BSS) interface; Data Link (DL) layer specification".
- [13] 3GPP TS 44.012: "Short Message Service Cell Broadcast (SMSCB) Support on the Mobile Radio Interface".
- [14] 3GPP TS 44.018: "Mobile radio interface layer 3 specification; Radio Resource Control Protocol".

- [15] 3GPP TS 44.031: "Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP)".
- [16] 3GPP TS 44.035: "Location Services (LCS); Broadcast Network Assistance for Enhanced Observed Time Difference (E-OTD) and Global Positioning System (GPS) Positioning Methods".
- [17] 3GPP TS 44.071: "Location Services (LCS); Mobile Radio Interface Layer 3 Location Services (LCS) specification".
- [18] 3GPP TS 48.008: "Mobile-services Switching Centre - Base Station System (MSC - BSS) interface; Layer 3 specification".
- [19] 3GPP TS 48.031: "Location Services (LCS); Serving Mobile Location Centre - Serving Mobile Location Centre (SMLC - SMLC); SMLCPP specification".
- [20] 3GPP TS 48.058: "Base Station Controller - Base Transceiver Station (BSC - BTS) interface; Layer 3 specification".
- [21] 3GPP TS 48.071: "Serving Mobile Location Center – Base Station System (SMLC-BSS) interface; Layer 3 specification".
- [22] 3GPP TS 49.031: "Location Services (LCS); Base Station System Application Part LCS Extension (BSSAP-LE)".
- [23] TIA/EIA/IS-J-STD-036 (2000): "Emergency Services Data Communications".
- [24] 3GPP TS 48.016: "General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN) interface; Network Service".
- [25] 3GPP TS 48.018: "General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN); BSS GPRS Protocol (BSSGP)".
- [26] 3GPP TS 44.064: "Mobile Station - Serving GPRS Support Node (MS-SGSN) Logical Link Control (LLC) layer specification".
- [27] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".
- [28] 3GPP TS 44.060: "General Packet Radio Service (GPRS); Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol".
- [29] 3GPP TS 25.410: "UTRAN Iu Interface: General Aspects and Principles".
- [30] 3GPP TS 25.411: "UTRAN Iu Interface Layer 1".
- [32] 3GPP TS 25.412: "UTRAN Iu Interface signalling transport".
- [33] 3GPP TS 25.413: "UTRAN Iu Interface RANAP signalling".
- [34] Void.
- [35] IETF STD 51, RFC 1661(07/1994): "The Point-To-Point Protocol (PPP)".
- [36] IETF STD 51, RFC 1662(07/1994): "PPP in HDLC-like Framing".
- [37] IETF RFC 2507(02/1999): "IP header compression".
- [38] IETF RFC 1990(07/1994): "The PPP Multilink Protocol (MP)".
- [39] IETF RFC 2686(09/1999): "The Multi-Class Extension to Multi-Link PPP".
- [40] IETF RFC 2509(02/1999): "IP Header Compression over PPP".
- [41] 3GPP TS 43.064: "General Packet Radio Service (GPRS); Overall description of the GPRS radio interface; Stage 2".
- [42] 3GPP TS 45.010: "Radio subsystem synchronization".

[43] 3GPP TS 43.020. "Security related network functions".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document the following terms and definitions apply and the terms and definitions given in 3GPP TS 22.101.

A/Gb mode: see 3GPP TS 43.051 [11].

Coverage Class: see 3GPP TS 43.064 [41].

EC-GSM-IoT: see 3GPP TS 43.064 [41].

EC operation: see 3GPP TS 43.064 [41].

Iu mode: see 3GPP TS 43.051 [11].

LCS (LoCation Services): LCS is a service concept in system standardisation. LCS specifies all the necessary network elements and entities, their functionality, interfaces, as well as communication messages, necessary to implement the positioning functionality in a cellular network.

NOTE 1: LCS does not specify any location based (value added) services except locating of emergency calls.

LCS Client: software and/or hardware entity that interacts with a LCS Server for the purpose of obtaining location information for one or more Mobile Stations. LCS Clients subscribe to LCS in order to obtain location information. LCS Clients may or may not interact with human users. The LCS Client is responsible for formatting and presenting data and managing the user interface (dialogue). The LCS Client may reside in the Mobile Station (MS).

LCS Server: software and/or hardware entity offering LCS capabilities. The LCS Server accepts requests, services requests, and sends back responses to the received requests. The LCS server consists of LCS components, which are distributed to one or more PLMN and/or service provider.

Location Estimate: geographic location of an MS and/or valid Mobile Equipment (ME), expressed in latitude and longitude data. The Location Estimate shall be represented in a well-defined universal format. Translation from this universal format to another geographic location system may be supported, although the details are considered outside the scope of the primitive services.

Location Request: request for a Location Estimate and optionally a Velocity Estimate.

Mobile Assisted positioning: any mobile centric positioning method (e.g. E-OTD, A-GNSS) in which the MS provides position measurements to the network for computation of a location estimate by the network. The network may provide assistance data to the MS to enable position measurements and/or improve measurement performance.

Mobile Based positioning: any mobile centric positioning method (e.g. E-OTD, A-GNSS) in which the MS performs both position measurements and computation of a location estimate and where assistance data useful or essential to one or both of these functions is provided to the MS by the network. Position methods where an MS performs measurements and location computation without network assistance data are not considered within this category.

Mobile Station: consists of Mobile or User Equipment (ME or MS) with a valid SIM or USIM attached.

Positioning (/location detecting): positioning is a functionality, which detects a geographical location (of e.g. a mobile terminal).

Positioning technology (/locating technology): technology or system concept including the specifications of RF interfaces, data types, etc. to process the estimation of a geographical location, e.g. A-GNSS and E-OTD.

Radio Interface Timing: Comprise Absolute Time Differences (ATDs) or Real Time Differences (RTDs) of the signals transmitted by Base Stations, where timing differences are measured relative to either some absolute time difference (ATD) or the signals of another Base Station (RTD).

RRLP maximum PDU size: maximum PDU size for the RRLP protocol, which is 242 octets.

RRLP pseudo-segmentation: use of several RRLP data messages to deliver a large amount of information.

Target MS: Mobile Station being positioned.

Type A LMU: accessed exclusively over the air interface (Um interface); there is no wired connection to any other network element.

Type B LMU: is accessed over the Abis interface from a BSC. The LMU may be either a standalone network element addressed using some pseudo-cell ID or connected to or integrated in a BTS.

Velocity Estimate: speed and bearing of an MS and/or valid Mobile Equipment (ME), expressed as speed in kilometres per hour and bearing in degrees measured clockwise from North.

NOTE 2: Abis interface is beyond the scope of the present document.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations and the abbreviations given in 3GPP TS 21.905 apply.

2G-	Second Generation
3G-	Third Generation
A	Interface between GERAN BSS and MSC
A-GNSS	Assisted GNSS
A-GPS	Assisted GPS
ATD	Absolute Time Difference
BDS	BeiDou Navigation Satellite System
BSSLAP	Base Station System Application Part
BSSAP-LE	Base Station System Application Part LCS Extension
CBC-BSC	Interface between CBC and BSC
CBC-SMLC	Interface between CBC and SMLC
D-GPS	Differential GPS
E-OTD	Enhanced Observed Time Difference
GNSS	Global Navigation Satellite System (e.g. GPS, Galileo)
Iu	Interface between GERAN BSS and 3G Core Network
Iu-cs	Interface between GERAN BSS and 3G MSC
Iu-ps	Interface between GERAN BSS and 3G SGSN
Gb	Interface between GERAN BSS and SGSN
Lb	Interface between SMLC and BSC
LCCF	Location Client Control Function
LCF	Location Client Function
LSBcF	Location System Broadcast Function
LSCF	Location System Control Function
LSOF	Location System Operation Function
MTA	Multilateration Timing Advance
PCF	Position Calculation Function
PRCF	Positioning Radio Co-ordination Function
PRRM	Positioning Radio Resource Management
PSMF	Positioning Signal Measurement Function
RIT	Radio Interface Timing
RRLP	Radio Resource Link Protocol
RTD	Real Time Difference
SMSCB	Short Message Service Cell Broadcast
SMLCPP	Serving Mobile Location Center Peer Protocol
TA	Timing Advance
UDT	SCCP Unitdata message
Um	GERAN Air Interface
UTC	Universal Coordinated Time
U-TDOA	Uplink Time Difference of Arrival

4 Main concepts

A general description of location services and the service requirements is given in the specification 3GPP TS 22.071. By measuring radio signals the capability to determine the geographic location of the mobile station (MS) shall be provided. The location information may be requested by and reported to a client (application) associated with the MS, or by a client within or attached to the Core Network. The location information may also be utilised internally by GERAN, for example to support features such as home location billing. The location information shall be reported in standard formats, such as those for cell based or geographical coordinates of the location of the MS.

It shall be possible for the majority of the MS (active or idle) within a network to use the feature without compromising the radio transmission or signalling capabilities of the GERAN.

Five positioning mechanisms are supported for LCS: Timing Advance (TA), Enhanced Observed Time Difference (E-OTD), Global Navigation Satellite System (GNSS) based positioning (A-GNSS), Uplink Time Difference Of Arrival (U-TDOA), and Multilateration based positioning.

4.1 Assumptions

- SMLC is either an integrated functionality in BSS or a standalone network element within GERAN.
- LMU is either an integrated functionality in BTS (Type B LMU) or a standalone network element (Type A LMU) where communication is over the Um interface.

4.2 Standard LCS Methods

4.2.1 Timing Advance

The TA is based on the existing Timing Advance (TA) parameter. The TA value is known for the serving BTS. To obtain TA values in case the MS is in idle mode a special procedure, not noticed by the GSM subscriber (no ringing tone), is set up. The cell-ID of the serving cell and the TA is returned as the result of the TA.

TA may be used to assist all positioning mechanisms.

4.2.2 Enhanced Observed Time Difference (E-OTD) positioning mechanism

The E-OTD method is based on measurements in the MS of the Enhanced Observed Time Difference of arrival of bursts of nearby pairs of BTSs. For E-OTD measurement synchronization, normal and dummy bursts are used. When the transmission frames of BTSs are not synchronized, the network needs to measure the Real or Absolute Time Differences (RTDs or ATDs) between them. To obtain accurate trilateration, E-OTD measurements and, for non-synchronized BTSs, RTD or ATD measurements are needed for at least three distinct pairs of geographically dispersed BTSs. Based on the measured E-OTD values the location of MS can be calculated either in the network or in the MS itself, if all the needed information is available in MS.

4.2.3 Global Navigation Satellite System (GNSS) based positioning mechanism

Global Navigation Satellite System (GNSS) refers to satellite systems that are set up for positioning purposes. Systems belonging to this category, that are operational today or will be in the near future are e.g., GPS, Galileo, Satellite Based Augmentation Systems (SBAS), Modernized GPS, Quasi Zenith Satellite System (QZSS), GLONASS and BDS.

A mobile station with GNSS measurement capability may operate in an autonomous mode or in an assisted mode for example MS-assisted or MS-based mode. In autonomous mode MS determines its position based on signals received from GNSS without assistance from network. In assisted mode, MS receives assistance data from network. MS may support one or several GNSSs and the assistance data content may vary depending on this capability.

A-GNSS refers to a concept which supports several global navigation satellite systems and their different navigation signals, including e.g. GPS, Galileo, Satellite Based Augmentation Systems (SBAS), Modernized GPS, Quasi Zenith

Satellite System (QZSS), GLONASS and BDS. The assistance data shall enable combined usage of satellite signals belonging to different GNSS or simple usage of one GNSS system independently from the other.

4.2.4 Uplink Time Difference of Arrival (U-TDOA) positioning mechanism

The U-TDOA positioning method is based on network measurements of the Time Of Arrival (TOA) of a known signal sent from the mobile and received at three or more LMUs. The known signal is the normal bursts generated by a mobile while in the dedicated mode; either on the SDCCH or TCH. The method requires LMUs in the geographic vicinity of the mobile to be positioned to accurately measure the TOA of the bursts. Since the geographical coordinates of the measurement units are known, the mobile position can be calculated via hyperbolic trilateration. This method will work with existing mobiles without any modification.

4.2.5 Multilateration Positioning Methods

4.2.5.1 Multilateration Timing Advance

This positioning method is based on one or more BSS acquiring Timing Advance (TA) information from a set of cells selected by the MS wherein the MS is triggered to perform MTA as a result of receiving a RRLP message from an SMLC indicating the MTA positioning method is to be used (see sub-clause 9.6.2). The MS sends a Multilateration access request in each of the cells it selects for performing the Multilateration Timing Advance procedure.

4.2.5.2 Multilateration OTD

This positioning method is based on measurements in the MS of the Observed Time Difference of arrival of bursts of a set of nearby BTSs relative to the serving BTS and reporting of these measurements to the serving BTS, similar as for the E-OTD positioning method, see subclause 4.2.2. The network provides assistance information to the MS about the co-sited neighbour cells to optimise the OTD measurements at MS. No LMUs are required for this positioning method. Based on the measured Multilateration OTD values and timing advance estimated with the serving base station, the location of the MS is calculated in the network.

5 GERAN LCS Architecture

Figure 1 shows the general arrangement of the Location Service feature. This illustrates, generally, the relation of LCS Clients and servers in the core network with the GERAN. The definition and operation of LCS entities operating in the core network is outside the scope of the present document. The LCS entities within the GERAN communicate with the Core Network (CN) across the A, Gb and Iu interfaces.

Communication among the GERAN LCS entities makes use of the messaging and signalling capabilities of the GERAN.

As part of their service or operation, the LCS Clients may request the location information of Mobile Station. There may be more than one LCS client. These may be associated with the core network, associated with the GERAN, operated as part of a MS application or accessed by the MS through its access to an application (e.g. through the Internet).

Within the GERAN, the BSC receives authenticated requests for LCS information from the core network across the A, Gb or Iu interface and passes these to the SMLC. The SMLC may be a standalone network element or functionality that is integrated to the BSC. LCS entities then manage the GERAN resources, including the base station, the LMU, the MS and calculation functions, to estimate the location of the MS and return the result to the Core Network.

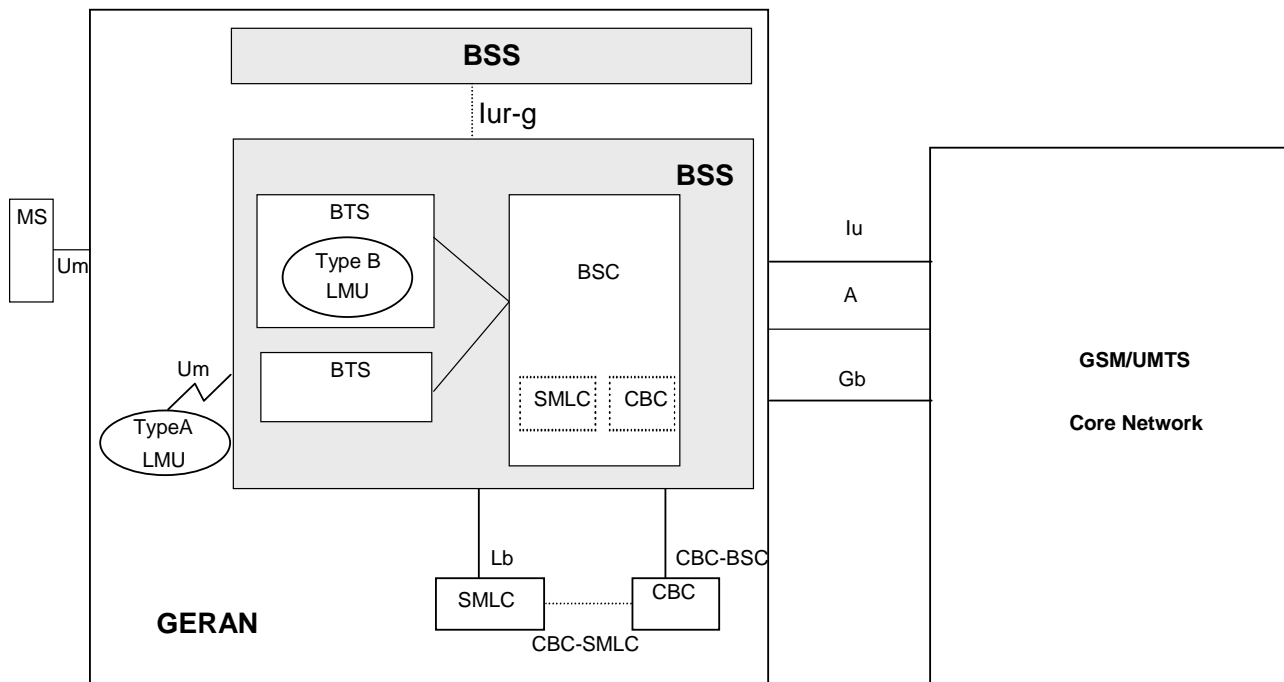


Figure 1: Functional LCS Architecture in GERAN

5.1 LCS Operations

The schematic functional description of LCS operations is defined in figure 2.

Upon request from the LCS entities or for internal operations, the GERAN LCS functional entities will:

- request measurements, typically from the MS and/or one or more BTS radio apparatus;
- send the measurement results to the appropriate calculating function within GERAN;
- receive the result from the calculating function within GERAN;
- send the results to the LCS entities in the core network or to application entities within GERAN.

In the event that the client is internal to GERAN the request may be made directly to the GERAN LCS entities as the internal clients are considered to be "pre-authorized".

As part of its operation, the GERAN LCS calculating function may require additional information. This may be obtained by the function directly by communication with a database, or it may be through a request to GERAN LCS entities that will mediate the request and return of information from the appropriate database (or databases if more than one is needed to fulfil the requests).

There may possibly also be available independent information that is able to supply the location information directly, or may be able to supply auxiliary information to the calculation function. The GERAN LCS co-ordination function, as part of its activity to supervise the location process, may query the MS or other elements of the GERAN to determine their capabilities and use this information to select the mode of operation.

This general operation is outlined in the following (generic) sequence diagram Figure 2. This figure is not intended to show the complete LCS operation for GERAN, but to simply to outline the basis for operation. Location measurements may continually be taken in the background.

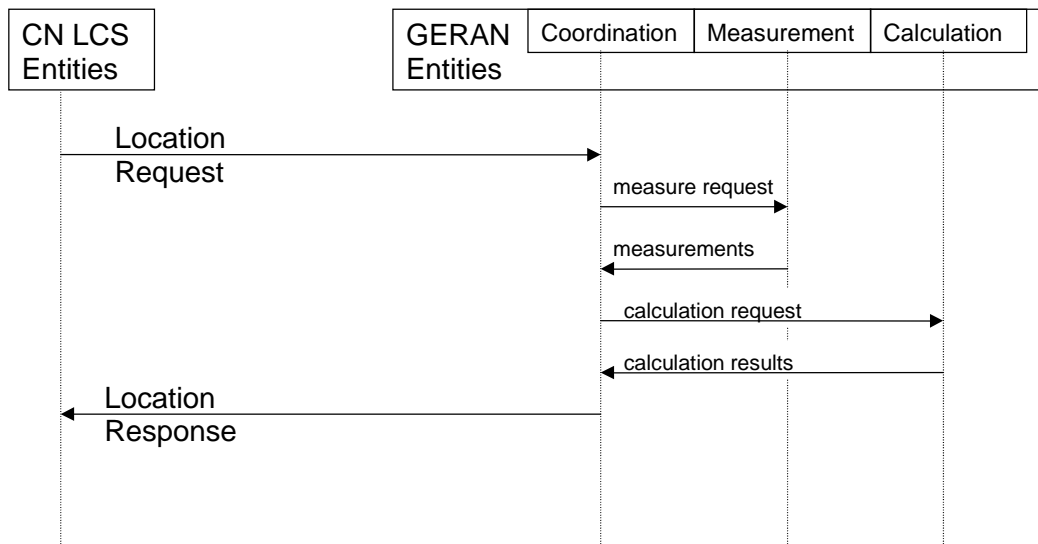


Figure 2: General sequence for LCS operation

5.2 High-Level Functions

Several functional groupings may be defined to describe the LCS. These groupings occur in both the Core Network and the GERAN. The overall LCS functional grouping is described in the system stage 2, 3GPP TS 23.271. Each grouping encompasses a number of functional components and functions.

The functions within the GERAN are described in more detail in the following clauses of the present document.

Within GERAN the functional entities may be grouped as follows:

- the Internal Client group;
- the GERAN System Handling group;
- the Positioning group.

The LCS functional diagram shown in figure 3 depicts the interaction of the LCS functional entities within the GERAN. The GERAN uses the various LCS components to provide the target MS Location Information to the internal LCS client.

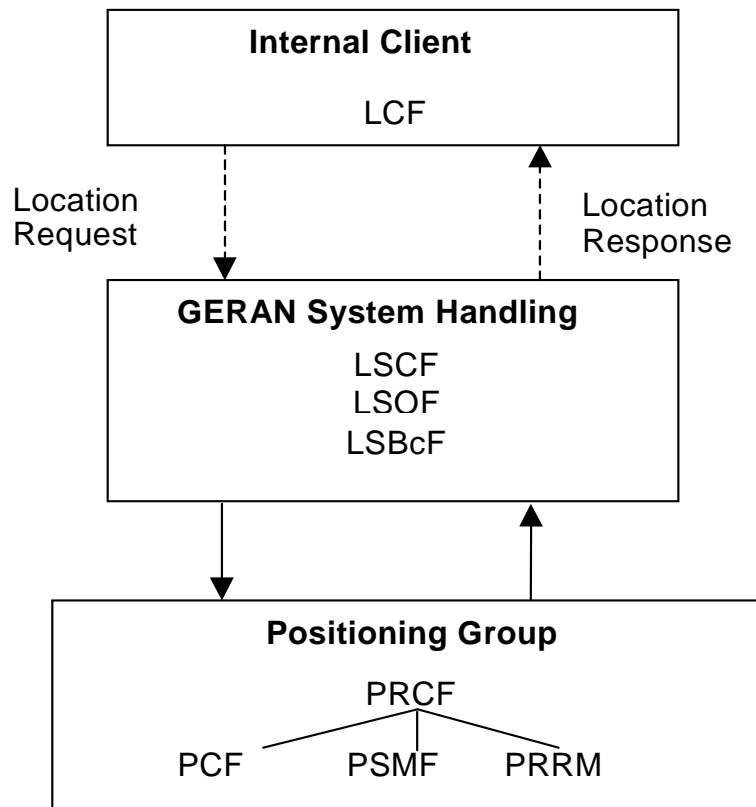


Figure 3: GERAN LCS Capability Functional Diagram

5.2.1 Co-ordination, Measurement and Calculation Functions

These GERAN functions (including functions in the System handling and Positioning groups) provide the co-ordination, measurement and calculation functions needed to provide a location estimate. The functions interface with the requesting application and select the appropriate location method and speed of response. The functions co-ordinate the operations of the radio and measurement equipment to transmit the needed signals and to make the needed measurements. The functions may also access databases or other sources of information appropriate for the location method. The functions also provide the calculation functions appropriate for the location method to estimate the MS location and the accuracy of the report. The functions also may record information on the usage of the LCS that may be used for administrative purposes (e.g. forwarded to a billing function in the Core Network). If needed by the location method, the functions will ensure the broadcast of information and gather and update information concerning GERAN operating parameters (e.g. timing of BTS transmissions) needed for LCS operations.

These entities are mainly concerned with the location method, controlling the radio equipment and performing the calculations to determine the location and thus may be associated with the SMLC in the GERAN. These functions may receive location requests from either the core network or from applications internal to the GERAN.

These functions communicate with the core network across the A, Gb and Iu interfaces, and with the BTS and LMU and with the MS across the Um interface.

5.3 GERAN LCS Functional Entities

5.3.1 Internal Client Group

5.3.1.1 Internal GERAN Location Client Function (LCF)

The Location Client Function (LCF) represents a logical interface between the internal GERAN LCS applications and the LCS BSC Handling entities (e.g. the Location System Control Function (LSCF) in the BSC).

NOTE: There is not necessarily a requirement for a LCCF (Location Client Control Function) for the GERAN Internal Client as is described for external clients in the system stage 2 specification, 3GPP TS 23.271.

The GERAN may make use of location information for internal operations such as location assisted handover. In such a case, a LCF representing the internal GERAN LCS application may communicate with the LSCF to request and receive the location information.

5.3.2 GERAN System Handling group

5.3.2.1 GERAN Location System Control Function (LSCF)

The GERAN Location System Control Function is responsible for co-ordinating location requests. This function manages call-related and non-call-related location requests and allocates network resources for handling them. This function "insulates" the Location clients in the Core Network from the detailed operation of the location method in order that the GERAN may be used by several types of core network and with several location methods.

The LSCF provides flow control between simultaneous location requests. Simultaneous location requests must be queued in a controlled manner to account for priority requests (e.g. for Emergency Clients). The details of the flow control, priority selection and queuing are beyond the scope of the present document.

The LSCF will select the appropriate location method based on the availability of resources and parameters of the location request. The LSCF coordinates resources and activities needed to obtain data (e.g. base station geographic coordinates) needed for the location method. It also records LCS usage data for the location service request that may be passed to a Location System Recording Function (LSRF) or O&M function in the Core Network.

5.3.2.2 GERAN Location System Operations Function (LSOF)

The Location System Operations Function (LSOF) is responsible for provisioning of data, location capabilities, data related to clients and subscription (LCS client data and MS data), fault management and performance management of LCS within the BSC.

An LSOF may be associated with each entity. The LSOF interacts with Internal (O&M) Clients for administration and maintenance of the data.

5.3.2.3 Location System Broadcast Function (LSBcF)

The Location System Broadcast Function (LSBcF) provides broadcast capability. The LSBcF capability is only used when broadcast data is required for E-OTD or A-GNSS positioning methods. Broadcast information (such as the geographic coordinates of the base stations) may be required, for example, to support a Position Calculation Function (PCF) located in the mobile station. These broadcasts may also include other information (such as currently observable satellites) that may assist a MS in the use of external location services.

The information to be broadcast is selected based on the location techniques offered for use by the LCS and the needs of the MS. This broadcast information may be specially coded (i.e. encrypted) to ensure its availability only to subscribers of the service. The use of broadcasts or other methods for signalling to the MS may be selected based on the chosen location method.

The information to be broadcast includes for example:

1. E-OTD Assistance:

- Reference Time;
- Neighbour Channel Time Slot Scheme;
- Information about sectored neighbour channels;
- Neighbour channel 51 Multiframe Offset values;
- Neighbour channel BCC values;
- RTD Drift Factor values (ciphered if active);
- Neighbour channel RTD values (ciphered if active);
- Serving cell and neighbour cell location information (ciphered if active).

2. A-GNSS Assistance Data:

- Broadcasted assistance data may be the same as in A-GNSS point-to-point signalling.

5.3.3 Positioning group

5.3.3.1 GERAN Position Radio Co-ordination Function (PRCF)

The GERAN Position Radio Control Function manages a location request for a MS through overall co-ordination and scheduling of resources to perform location measurements. This function interfaces with the PSMF, the PRRM and the PCF. The PRCF determines the location method to be used based on the location request, the QoS, the capabilities of the GERAN, and the MS's capabilities. The PRCF also manages the needed radio resources through the PRRM. It determines which PSMFs are to be involved, what to measure, and obtains processed signal measurements from the PSMF.

Some location methods may involve measurements made at the MS. In this case the PRCF interfaces with the MS to obtain the measurements (or the location results if they have been determined by the MS). Some location methods may involve measurements or information from several sources, including radio units at several BTSs and involve a series of transmissions and receptions. The PRCF entity also provides ancillary measurements in case of network-assisted location method. Ancillary information may be extracted from navigating systems like GNSS.

The PRCF forwards the signal measurement data to the PCF.

It is the function of the PRCF to co-ordinate the sequence of activities and compensate for failures (if they occur) to provide the location estimate.

5.3.3.2 GERAN Position Calculation Function (PCF)

The GERAN Position Calculation Function is responsible for calculating the location of the MS. This function applies an algorithmic computation on the collected signal measurements to compute the final location estimate and accuracy.

The PCF would also be responsible for calculating the speed and bearing of the MS when reported. This function applies an algorithmic computation on the collected signal measurements to compute the final velocity estimate and uncertainty.

It may obtain related data (e.g.: base station geographic coordinates) needed for the calculation. There may be more than one calculating function available within, or associated with, the calculation function of the GERAN.

The Position Calculation Function is also responsible for estimating the accuracy of the location estimate.

5.3.3.3 GERAN Position Signal Measurement Function (PSMF)

The GERAN Position Signal Measurement Function (PSMF) is responsible for performing and gathering uplink or downlink radio signal measurements for use in the calculation of a MS's location and velocity. These measurements can be location related or ancillary.

There may be one or more PSMF within a GERAN and they may be located at the MS or a Location Measurement Unit (LMU). The PSMF, generally, may provide measurement of signals (i.e. satellite signals) in addition to measurements of the GERAN radio transmissions. The measurements to be made will depend on the selected location method.

5.3.3.4 GERAN Position Radio Resource Management (PRRM)

The GERAN Position Radio Resource Management entity is responsible for managing the effect of LCS operations on the overall performance of the radio network. This may ensure, for example, that the operation of the PSMF does not degrade the QoS of other calls.

5.4 Assignment of LCS Functional Entities to GERAN Elements

The following Table 1 shows the generic configuration for different location methods, including network-based, mobile-based, mobile-assisted and network-assisted methods. With this approach both the network and the mobiles are able to measure the timing of signals and compute the mobile's location and velocity estimate. Depending on the applied location method it is possible to utilise the corresponding configuration containing all needed entities. For instance, if a network-based location method is applied, the entities that are involved in measuring the mobile's signal and calculating its location estimate are allocated to the network elements of the access network. On the other hand, in case mobile-based or network-assisted methods are used these entities should be allocated to the mobile station.

Table 1: Example Allocation of LCS Functional Entities to Network Elements

	MS	LMU	SMLC	BSC
LCF	X			X
LSBcF			X	
LSCF				X
PRCF			X	
PCF	X		X	
PRRM				X
PSMF	X	X		
LSOF		X	X	X

5.5 Functional Description of GERAN LCS Network Elements

5.5.1 BSC

The BSC receives authenticated requests for LCS information from the CN across A, Gb and Iu interfaces and passes these to the SMLC.

5.5.2 SMLC

The SMLC is either a separate network element of GERAN or integrated functionality in BSC that contains functionality required to support LCS. The SMLC manages the overall co-ordination and scheduling of resources required for the location of a mobile. It also calculates the final location and velocity estimate and estimates the achieved accuracy. The SMLC may control a number of LMUs for the purpose of obtaining radio interface measurements to locate or help locate MS subscribers in the area that it serves. The SMLC is administered with the capabilities and types of measurement produced by each of its LMUs (only applicable for positioning methods that make use of LMUs).

5.5.3 CBC

For Location Services, when a Cell Broadcast Center (CBC) is associated with a BSC, the SMLC may interface to a CBC in order to broadcast assistance data using existing cell broadcast capabilities. The SMLC shall behave as a user, Cell Broadcast Entity, to the CBC (refer to 3GPP TS 23.041).

5.5.4 LMU

The LCS Measurement Unit (LMU) entity makes measurements (e.g. of radio signals) and communicates these measurements to the SMLC (e.g. the PRCF). The LMU contains a PSMF and may also perform calculations associated with the measurements. The LMU may make its measurements in response to requests (e.g. from the SMLC), or it may autonomously measure and report regularly (e.g. timing of BTS transmissions) or when there are significant changes in radio conditions (e.g. changes in the RTD). There may be one or more LMUs associated with the SMLC and an LCS request may involve measurements by one or more LMUs. LMU functionality may be integrated in a BTS. The Multilateration based positioning methods does not make use of LMUs.

An LMU makes radio measurements to support one or more positioning methods; these assistance measurements are specific to all MSs in a certain geographic area. All location and assistance measurements obtained by an LMU are supplied to the SMLC associated with the LMU. Instructions concerning the timing, the nature, and any periodicity of these measurements are either provided by the SMLC or are pre-administered in the LMU.

The following assistance measurement obtained by an LMU has a generic status usable by more than one position method:

- Radio Interface Timing measurements – comprise Absolute Time Differences (ATDs) or Real Time Differences (RTDs) of the signals transmitted by Base Stations, where timing differences are measured relative to either some absolute time difference (ATD) or the signals of another Base Station (RTD).

5.5.5 MS

The MS interacts with the measurement co-ordination functions to make measurements of downlink signals. The measurements to be made will be determined by the chosen location method.

The MS may also contain LCS applications, or access an LCS application through communication with a network accessed by the MS or an application residing in the MS and/or satellite signals. The MS may include the needed measurement and calculation functions to determine the MS's location with or without assistance of the GERAN LCS entities.

6 Signalling Protocols and Interfaces

6.1 Protocol layering in A/Gb mode

6.1.1 Generic Signalling Model

Figure 4 shows the generic signalling model applicable to LCS for signalling interaction in which an SMLC forms at least one of the signalling end points.

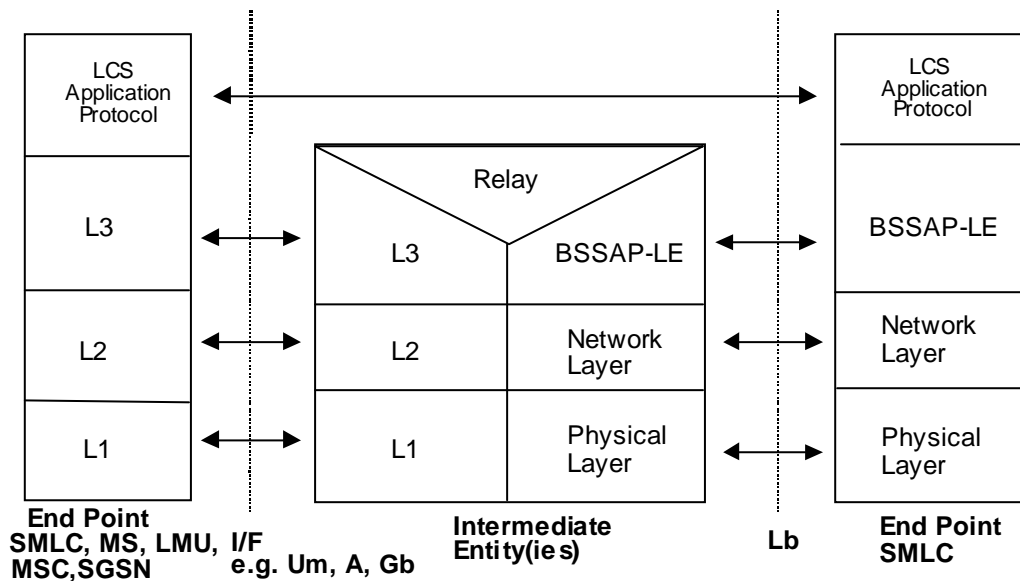


Figure 4: Generic Model for LCS Signalling to an SMLC

The functions performed by each protocol layer are as follows:

- a) LCS application protocol – this depends on the other signalling end point (e.g. whether a target MS or LMU) and may be absent if supported in the BSSAP-LE layer. The application protocol supports specific LCS functions (e.g. positioning measurements, assistance measurements) and is independent of lower protocol layers.
- b) BSSAP-LE – this is an extension of BSSAP and carries the LCS application protocol signaling units. Necessary functions include identification of the LCS application protocol and identification, where not provided by the network layer, of the two end points. This layer can be relayed by an intermediate entity or mapped into an equivalent layer 3 protocol used by the other signaling end point. This layer supports segmentation of LCS application layer protocols.
- c) Network Layer – provides signaling transport between the SMLC and either the other end point or some intermediate entity at which the BSSAP-LE layer is relayed or mapped. The network layer may support connection oriented or connectionless signaling. For second generation circuit oriented applications, the network layer is provided using either MTP or M3UA/SCTP and SCCP. This layer supports segmentation of LCS application layer protocols.
- d) Physical Layer – When MTP is used as transport protocol, SS7 signaling links are supported by the physical layer. It is recommended that when IP transport (via M3UA/SCTP) is used, the data link layer is implemented using Ethernet. A node using IP transport having interfaces connected via low bandwidth PPP links like E1/T1 shall also support IP Header Compression [37] and the PPP extensions ML/MC-PPP [38], [39]. In this case, the negotiation of header compression [37] over PPP shall be performed according to [40].
- e) L3 – a protocol layer compatible with or the same as BSSAP-LE.
- f) L2 – logical link layer for the other endpoint
- g) L1 – physical layer for the other end point.

6.1.2 Message Segmentation in A/Gb mode

Message segmentation is needed to transport any large LCS message that exceeds the message size limitation supported by any GSM interface over which transport is needed.

6.1.2.1 Network Level Segmentation

Segmentation and reassembly of large SMLCPP messages at the network (e.g. SCCP) level may be supported. For message transfer over any interface where network level segmentation is not supported, segmentation at the application level shall be used. This may require support of both network and intermediate level segmentation by certain intermediate entities.

6.1.2.2 Intermediate Level Segmentation

The segmentation of SMLCPP 3GPP TS 48.031[19], messages is supported by segmentation mechanisms defined in 3GPP TS 48.008 [18], and 3GPP TS 49.031[22]. The sending, receiving and all intermediate entities supporting segmentation shall ensure reliable and sequenced delivery of the message segments by appropriate use of the capabilities supported by lower transport and network level protocols.

For support of legacy (Rel4 and older) MS and GERAN, there are segmentation mechanisms defined in the RR layer (3GPP TS 44.018 [14]) and BSSAP-LE layer (3GPP TS 49.031 [22]) for segmentation of RRLP (3GPP TS 44.031) messages, which need to be supported by the MS, BSS, and SMLC in the uplink direction in the CS domain and by the MS and BSS for the downlink direction in the CS domain.

6.1.2.3 RRLP Pseudo-Segmentation

The use of several RRLP messages to deliver a large amount of information is called "RRLP pseudo-segmentation". If more information than what fits in the RRLP maximum PDU size needs to be delivered, the RRLP pseudo-segmentation shall be used. (For Rel 4 or older MS and GERAN, may also use intermediate level segmentation).

6.1.3 Signalling between an SMLC, MSC and BSC

An SMLC can either be separate logical entity or integrated functionality in the BSC. If the SMLC is a separate logical entity, the LCS signalling between SMLC and MSC is accomplished through the A and Lb interfaces. If the SMLC is integrated, the LCS signalling is accomplished through the A interface only. Figure 5 shows the protocol layers used to support LCS signaling between the SMLC, MSC and BSC.

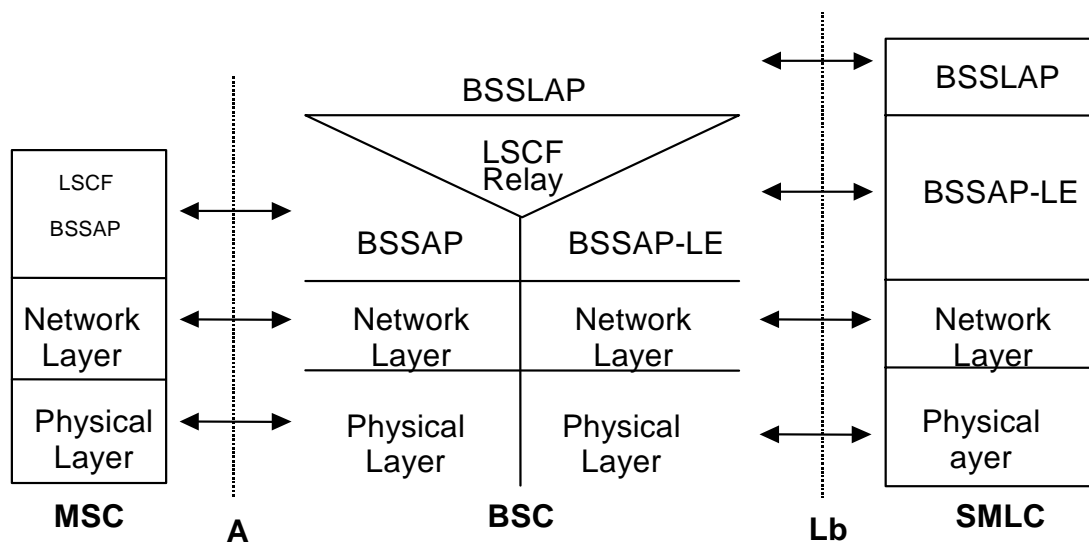


Figure 5: Signalling Protocols between SMLC, MSC and BSC

6.1.3a Signalling between an SMLC, SGSN and BSS

An SMLC can either be separate logical entity or integrated functionality in the BSS. If the SMLC is a separate logical entity, the LCS signalling between SMLC and SGSN is accomplished through the Gb and Lb interfaces. If the SMLC is integrated, the LCS signalling is accomplished through the Gb interface only. Figure 5a shows the protocol layers used to support LCS signaling between the SMLC, SGSN and BSS. Notice that the Network Service layer may be based on frame relay or IP (see 3GPP TS 48.016 [24]).

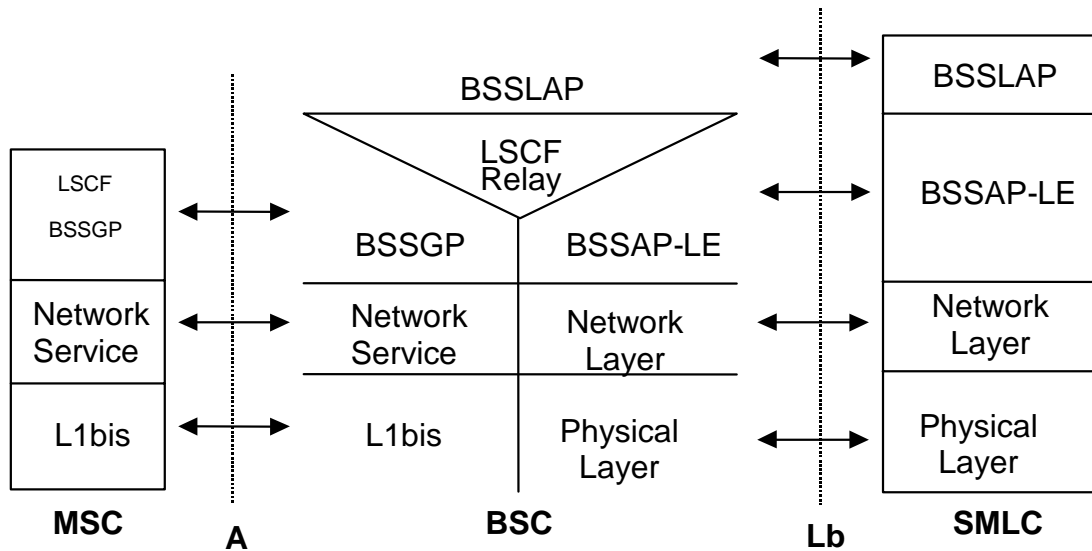


Figure 5a: Signalling Protocols between SMLC, SGSN and BSS

6.1.4 Signaling between SMLC and MS

SMLC Signalling to a target MS is accomplished through the Um interface. Figure 6 shows the protocol layers used to support signaling between an SMLC and target MS in the CS domain.

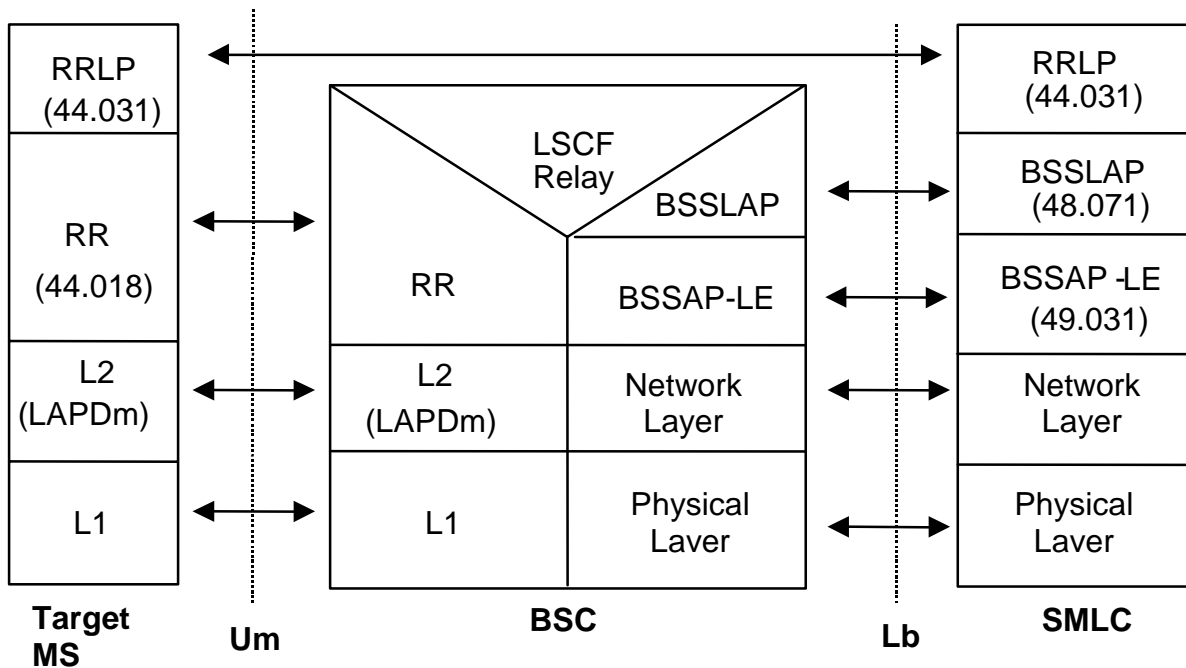
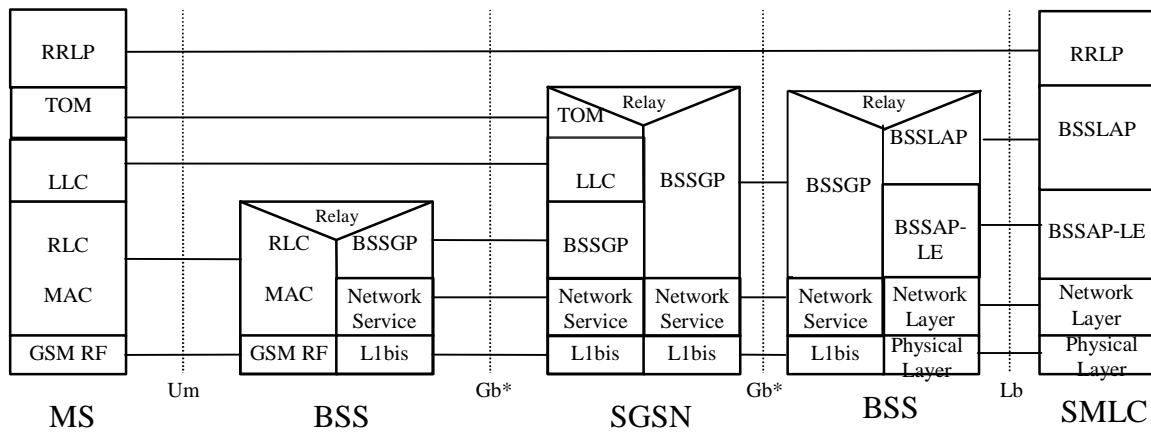


Figure 6: Signalling between an SMLC and Target MS in CS domain

Figure 6a shows the protocol layers used to support signaling between an SMLC and target MS in the PS domain. The signalling is routed through the core network to utilize standard GPRS functions. BSSGP is specified in 3GPP TS 48.018 [25] and RLC/MAC is specified in 3GPP TS 44.060 [28]. The TOM and LLC protocols are specified in 3GPP TS 44.064 [26]. The TOM Protocol Header for RRLP is specified in 44.031 [15]. For an overview of GPRS, see 3GPP TS 23.060 [27].



NOTE*: The network layer for the Gb interface may be based on IP or frame relay.

Figure 6a: Signalling between an SMLC and Target MS in PS domain

6.1.5 SMLC Signalling to a Type A LMU

Notice that the signalling to a Type A LMU is using CS signalling over the Um interface. A Type A LMU can be used to support positioning of mobile stations both in the CS and the PS domain.

6.1.5.1 Circuit Switched Signalling using an SDCCH

Figure 7 shows the protocol layers used to support signaling between an SMLC and a Type A LMU, using an SDCCH on the Um interface.

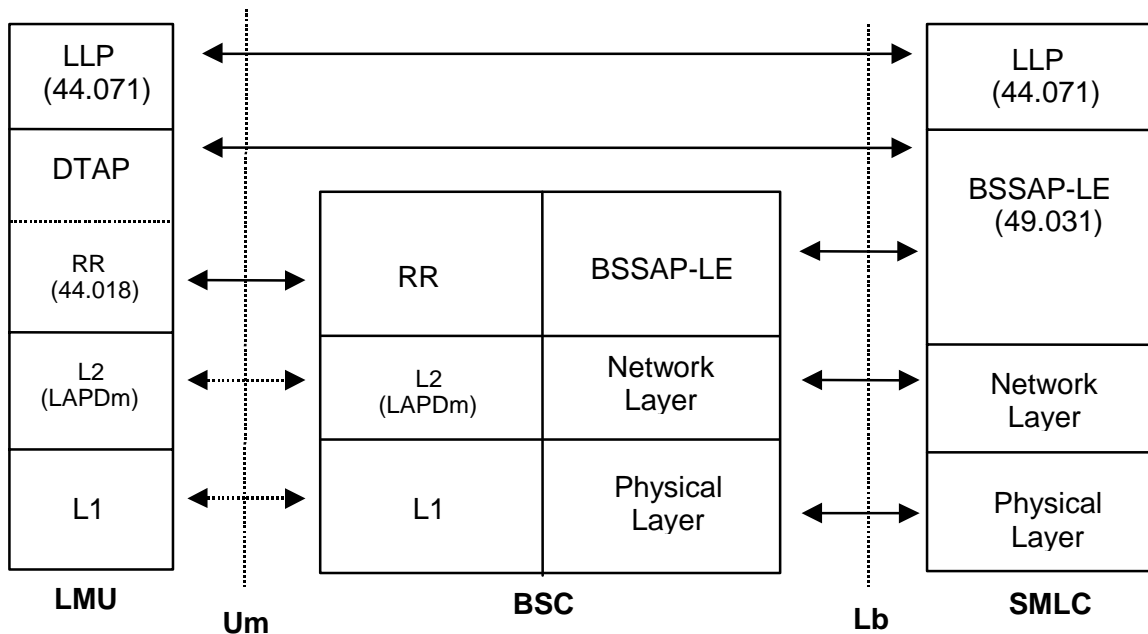


Figure 7: Signalling between an SMLC and Type A LMU using an SDCCH

6.1.5.2 Signalling using a TCH

Figure 8 shows the protocol layers that can be used to support signaling between an SMLC and a Type A LMU using a TCH on the Um interface. The TCH is assumed to support either transparent or non-transparent synchronous data and

may be provided in a multislot configuration. The main usage would be for O&M data and SW download – e.g. during offpeak hours.

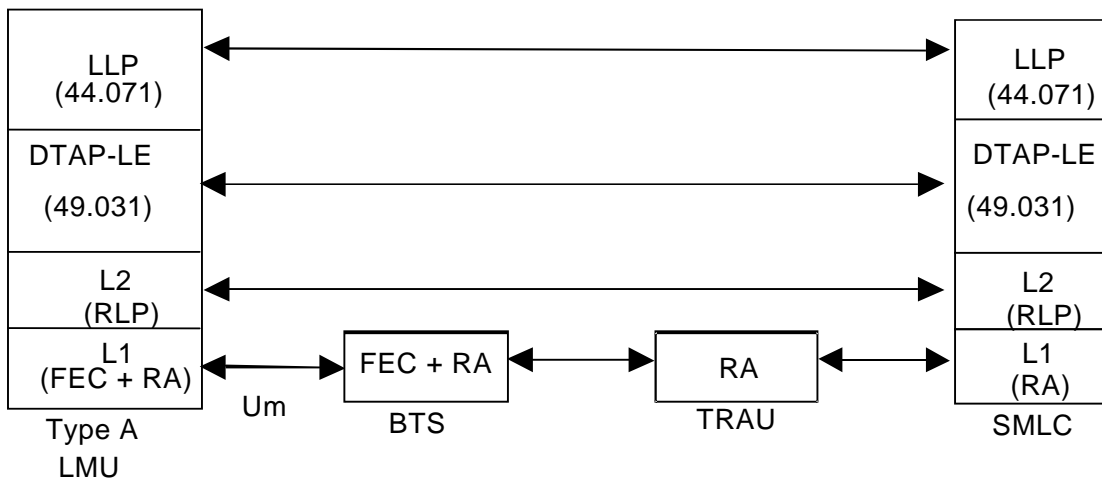


Figure 8: Signalling between an SMLC and a Type A LMU using a TCH

6.1.6 SMLC signalling to a Type B LMU

The protocol layers employed to enable signalling between the SMLC and a Type B LMU are shown in figure 9. Notice that the signalling to a Type B LMU can be used to support positioning of mobile stations both in the CS and the PS domain.

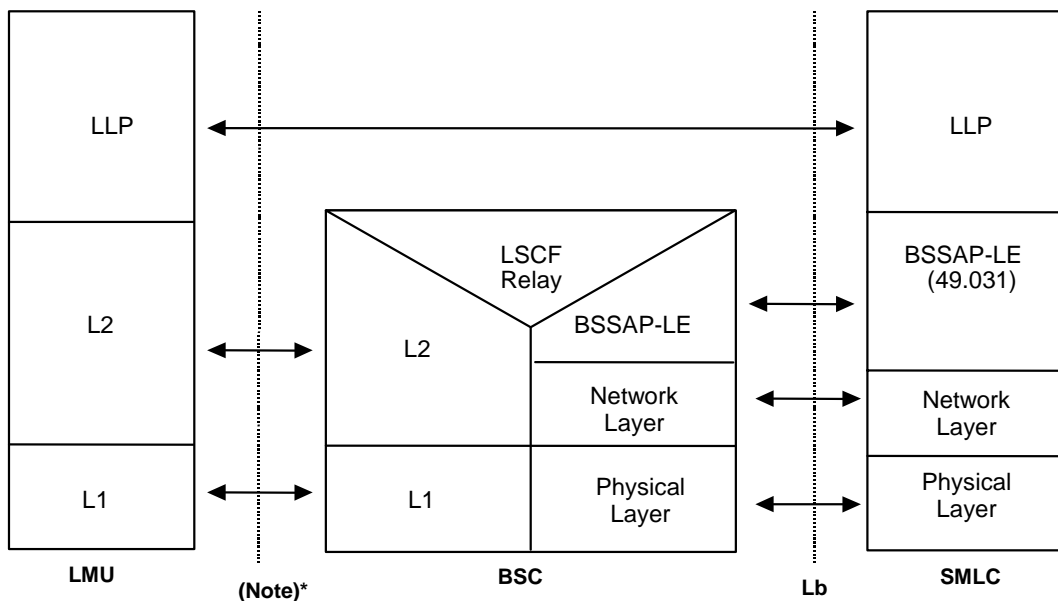


Figure 9: Signalling between an SMLC and Type B LMU

NOTE*: Abis interface is beyond the scope of the present document.

6.1.7 SMLC Signalling to a peer SMLC

The protocol layers used for SMLC to SMLC signalling are shown in figure 10, where it is assumed that both SMLCs have connections to an intermediary signalling network (or there is a direct link between the SMLCs).

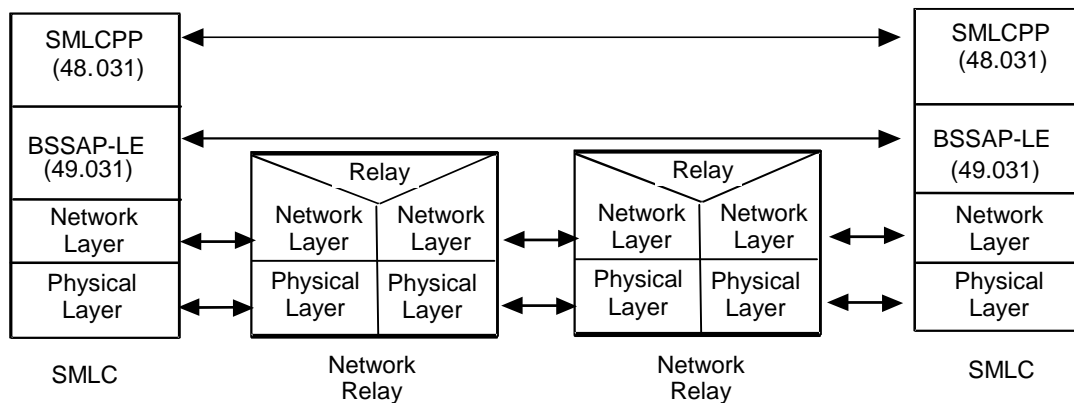


Figure 10: SMLC to SMLC Signalling via an intermediary signalling network

In the absence of either a direct link or links to an intermediary signalling network, signalling can go via attached BSCs and MSCs as shown in figure 11 for signalling between the SMLCs sharing the same MSC.

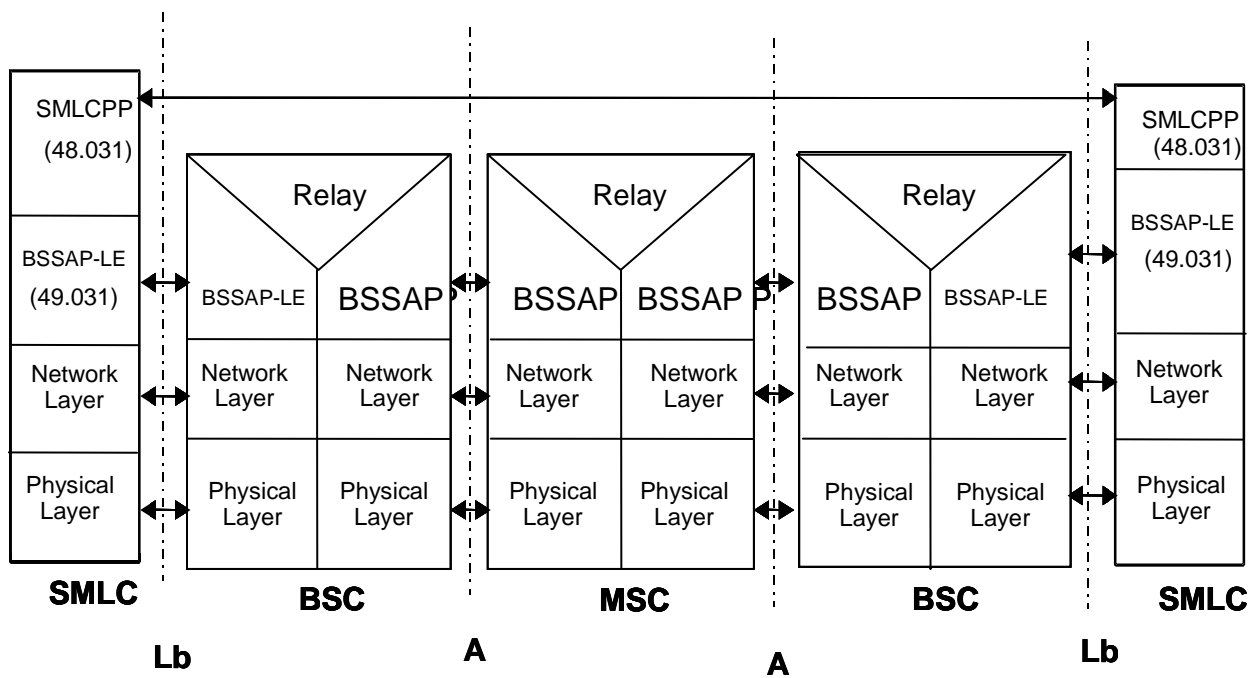


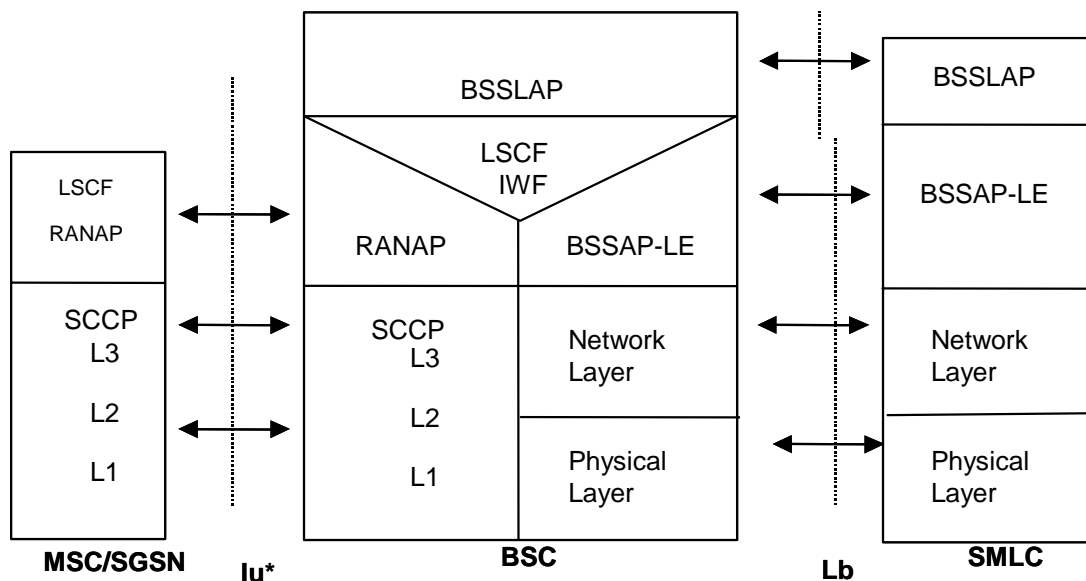
Figure 11: SMLC to SMLC Signalling via associated BSCs and MSC

6.2 Protocol layering in Iu mode

6.2.1 Signalling between SMLC and MSC/SGSN

A SMLC can either be a separate logical entity or integrated functionality in the BSC. If the SMLC is a separate logical entity, the LCS signalling between SMLC and MSC/SGSN is accomplished through the Iu and Lb interfaces. If the

SMLC is integrated, the LCS signalling is accomplished through the Iu interface only. Figure 11a shows the protocol layers used to support LCS signaling between the SMLC, BSC and MSC/SGSN.



NOTE: * Iu protocol stack is inherited from UMTS specifications [29-32]. See GERAN Stage 2 specification [11] for additional transport layer options.

Figure 11a: Signalling Protocols between SMLC, BSC and MSC/SGSN

6.2.2 Signalling between SMLC and MS

SMLC Signalling to a target MS is accomplished through the Um interface. Figure 11b shows the protocol layers used to support signaling between an SMLC and target MS.

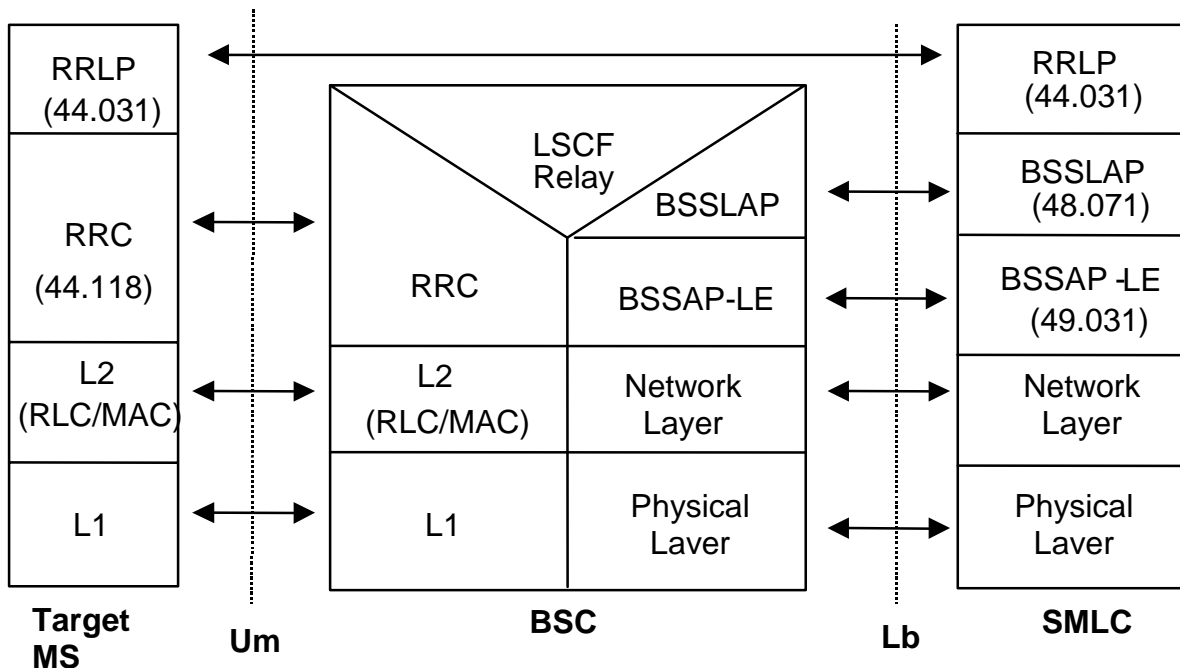


Figure 11b: Signalling between an SMLC and Target MS

6.2.3 SMLC signalling to a Type A LMU

The signalling to a Type A LMU is defined using A/Gb Mode CS signalling over the Um interface, see Clause 6.1.5. A Type A LMU operating in A/Gb Mode CS Domain can be used to support positioning of mobile stations operating in Iu Mode. Signalling to a Type A LMU in Iu Mode is FFS.

6.2.4 SMLC signalling to a Type B LMU

The signalling to a Type B LMU is defined in Clause 6.1.6. A Type B LMU operates independently of the mode of the MS (A/Gb Mode or Iu Mode) and signalling to a Type B LMU as defined in Clause 6.1.6 can be used to support positioning of mobile stations operating in Iu Mode.

6.2.5 SMLC signalling to a peer SMLC

The signalling to a peer SMLC is defined in Clause 6.1.7. A peer SMLC connection and signaling is independent of the mode of the MS (A/Gb Mode or Iu Mode) and signalling to a peer SMLC as defined in Clause 6.1.7 can be used to support positioning of mobile stations operating in Iu Mode.

7 GERAN Network Location Procedures

7.1 State description for SMLC

7.1.1 SMLC States

7.1.1.1 NULL State

This is a conceptual rather than actual state in which a certain location request from a particular Location Client, VMSC, SGSN or BSC either has not yet been received or has been completed.

7.1.1.2 LOCATION State

This state exists after the SMLC has received a location request from a BSC and persists while the SMLC is obtaining position measurements for a particular positioning method until such time as positioning measurements have been received and a location estimate (with optional velocity estimate) has been computed and returned to the BSC.

When sufficient positioning measurement results have been received, the SMLC either evaluates them, if they include an already computed location estimate, or uses them to compute a location estimate. The SMLC then has the option of either reinitiating another positioning attempt, e.g. if the location estimate did not satisfy the required QoS and the requirement on response time permits another position attempt, or returning the location estimate to the BSC.

7.1.2 State Functionality

7.1.2.1 State Transitions

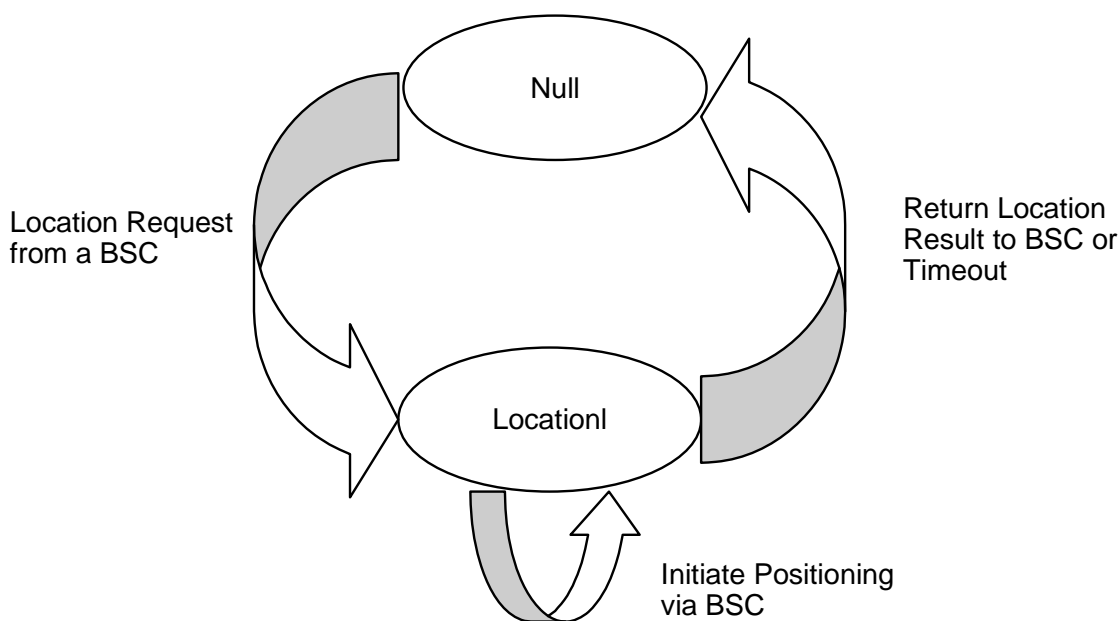


Figure 12: State Transitions in the SMLC

Moving from NULL to LOCATION state: After a location request is received from the BSC, the SMLC enters the LOCATION state. It then chooses a positioning method and initiates the appropriate position measurements.

Moving from LOCATION to NULL state: When the SMLC has obtained a location estimate that best meets the requested QoS parameters, it returns this to the BSC and re-enters the NULL state.

7.1.2.2 LOCATION Timer Function

The SMLC runs a timer while in the LOCATION state to limit the total amount of time that positioning can be active. This timer should be related to any response time indicated in the location request QoS parameters. If the timer expires before a final location estimate has been produced, the SMLC either returns the best existing location estimate (with optional velocity estimate) to the BSC (e.g. an estimate based on the current cell ID) or returns a failure indication. It then re-enters the NULL state.

7.2 State Description for the BSC

7.2.1 BSC States

7.2.1.1 IDLE State

In this state, the BSC location service is inactive for a particular MS.

7.2.1.2 LOCATION State

In this state, the BSC is awaiting a response from an SMLC after requesting the location for a particular MS. In this state, a Radio Resource connection to the target MS will be active – allowing the SMLC and MS to exchange positioning related messages for mobile based and mobile assisted position methods. For certain position methods (e.g. network based position methods), the SMLC may invoke substates in the BSC during which other types of association or procedure are supported with the MS (e.g. temporary call establishment, handover). In this state, the BSC may transfer positioning related messages between the SMLC and the target MS and/or between the SMLC and certain LMUs served by the BSC.

7.2.2 State Functionality

7.2.2.1 State Transitions

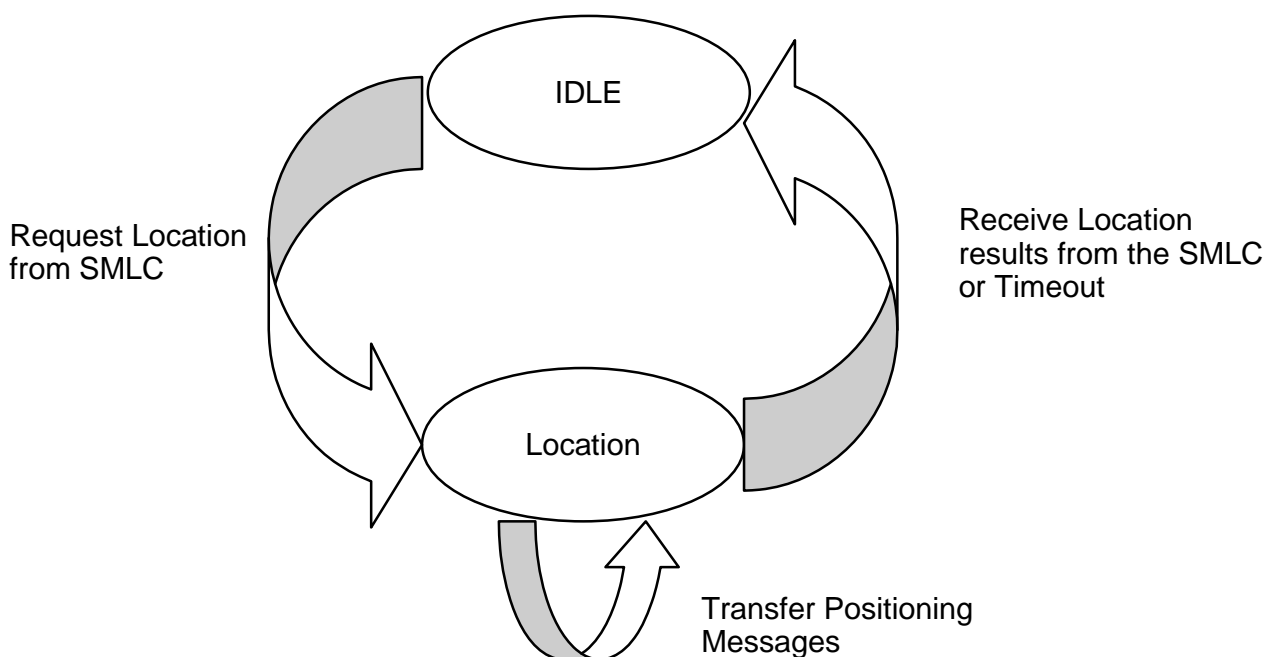


Figure 13: State Transitions in the BSC

Moving from IDLE to LOCATION state: After a request has been received to locate a particular MS served by the BSC, a location request is sent to the SMLC associated with the serving cell: the BSC then enters the LOCATION state. Before entering this state, a Radio Resource connection to the MS must have been already established by the VMSC.

Moving from LOCATION to IDLE state: After the return of a location estimate result from the SMLC, the BSC shall re-enter IDLE state.

7.2.2.2 LOCATION Timer Function

The BSC runs a timer while in the LOCATION state to limit the amount of time waiting for a location response from the SMLC. If the timer expires before such information is received, the BSC indicates a location failure to the original requesting entity and re-enters IDLE state.

7.3 Usage of SCCP Connection on the Lb interface in the CS domain in A/Gb mode

SCCP connection oriented signalling between an SMLC and a BSC is used to support SMLC signalling to a Type A LMU, a serving BSC, or a target MS. The types of SCCP connections are described below.

7.3.1 SCCP Connection for positioning of a target MS

The BSC establishes this connection when a request is received for a location estimate for a target MS in the CS domain. The BSC sends the BSSAP-LE Perform Location Request to the SMLC inside an SCCP Connection Request message. Signaling between the SMLC and target MS, if required, is then relayed by the BSC between this SCCP connection and the main signaling link to the MS. The same SCCP connection is also used to transfer BSSLAP messages between the SMLC and serving BSC. See Figure 14.

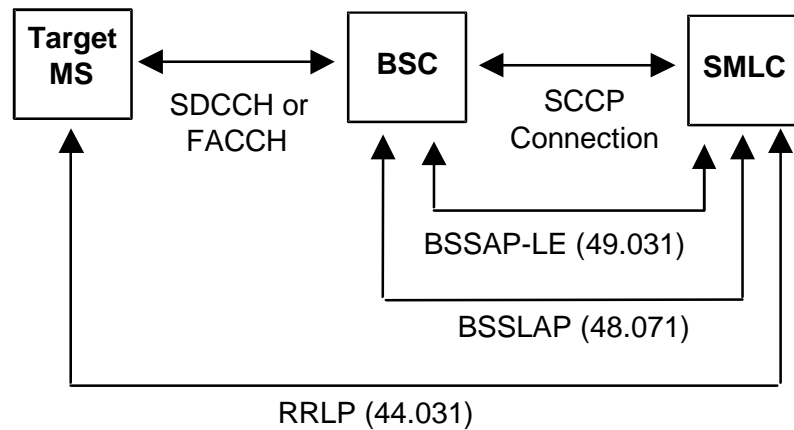


Figure 14: SCCP based signalling for MS positioning with an SMLC in CS domain

7.3.2 SCCP connection to access a Type A LMU

The BSC or SMLC establishes this connection to enable LCS messages to be transferred to or from a Type A LMU. The BSC or SMLC sends a BSSAP-LE LMU Connection Request message inside an SCCP Connection Request message. Signaling is subsequently relayed through the BSC using this SCCP connection as shown in figure 15.

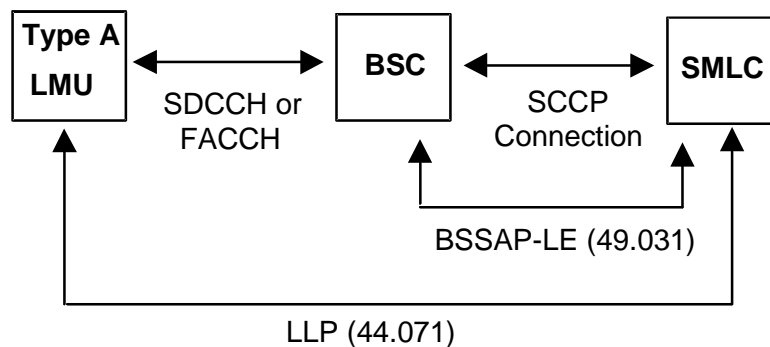


Figure 15: SCCP based signalling to access a Type A LMU with an SMLC

7.4 Usage of SCCP Connection on the Lb interface in the PS domain in A/Gb mode

SCCP connection oriented signalling between an SMLC and a BSS is used to support SMLC signalling to a serving BSS or a target MS. The types of SCCP connections are described below.

7.4.1 SCCP Connection for positioning of a target MS

The BSS establishes this connection when a request is received for a location estimate for a target MS in the PS domain. The BSS sends the BSSAP-LE Perform Location Request to the SMLC inside an SCCP Connection Request message. Signaling between the SMLC and target MS is then relayed by the BSS via the SGSN to the MS. The same SCCP connection is also used to transfer BSSLAP messages between the SMLC and serving BSS. See figure 15a below. RRLP Messages between the SMLC and the MS are carried in BSSGP Position Command/Response messages (see 3GPP TS 48.018) across the Gb interface and in TOM messages in LLC UI frames (see 3GPP TS 44.064 [26]) across the Um interface. Because a connectionless mode of communication is used to transport BSSGP and LLC, an MS identity is included in each message for those protocols.

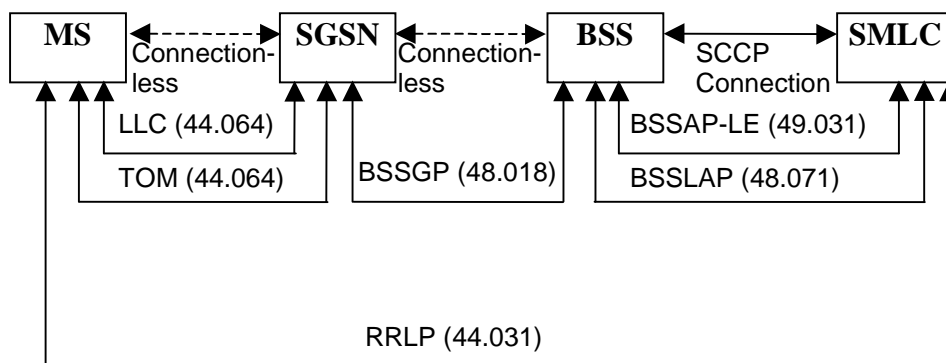


Figure 15a: SCCP based signalling for MS positioning with an SMLC in PS domain

8 Common Procedures to Support Positioning

The procedures described in this clause enable an SMLC to obtain positioning related information or instigate positioning for a particular target MS. The procedures are applicable to all positioning methods after an SMLC receives a BSSAP-LE Perform Location request for a target MS until a BSSAP-LE Perform Location response is returned to the originator.

8.1 Information Transfer between an SMLC and a Target MS in the CS Domain in A/Gb mode for E-OTD and A-GNSS positioning methods

An SMLC uses the procedure shown below in order to obtain the MS position or positioning measurements from a target MS or transfer location assistance information to a target MS in the CS domain after a request has been received from the BSC serving the target MS. More details of the location information transfer procedure between the BSC and MS can be found in 3GPP TS 24.008.

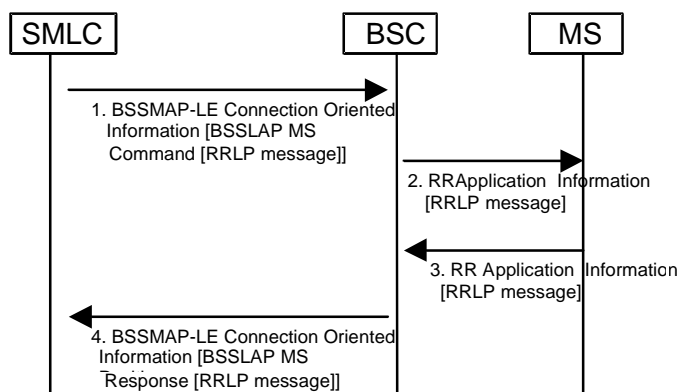


Figure 16: Information Transfer between an SMLC and a Target MS in CS domain

- 1) The SMLC passes a BSSAP-LE Connection Oriented Information message to the serving BSC containing an embedded BSSLAP MS Position Command with an RRLP message parameter. The message is transferred using the SCCP connection established between the SMLC and BSC for positioning the target MS. If the BSSLAP message is too large to fit in a single BSSAP-LE Connection Oriented Information message, RRLP pseudo-segmentation shall be used. Legacy SMLC may utilize BSSAP-LE layer segmentation instead of RRLP pseudo-segmentation. The SMLC shall indicate in the first BSSLAP MS Position Command whether the embedded RRLP message contains a positioning command versus positioning assistance data.

- 2) The BSC transfers the embedded RRLP message to the target MS inside an RR Application Information message. No later than when the RR Application Information message has been transferred, the BSC shall start a positioning supervision timer if none is already in progress or restart this if already in progress. If the timer expires before the final response in step 3 is received, the BSC shall return a BSSAP-LE Connection oriented Information message to the SMLC containing a BSSLAP Abort with a cause of BSC timeout.
- 3) When the target MS has positioning information to return to the SMLC, it sends an RR Application Information message to the BSC containing an embedded RRLP message. If the RRLP message is too large to fit in a single RR Application Information message, RRLP pseudo-segmentation shall be used. Legacy MS may utilize RR layer segmentation instead of RRLP pseudo-segmentation. . The last RR Application Information message shall indicate if this is the final response from the MS.
- 4) If the timer started in step 2 has already expired, the BSC discards the RRLP message received in step 3. Otherwise, the BSC forwards the RRLP message to the SMLC inside a BSSLAP MS Positioning Response message contained in a BSSAP-LE Connection Oriented Information message. If the SMLC indicated a positioning command in step 1 and the MS has indicated a final response, the BSC may add additional measurement information to the BSSLAP MS Position Response in the last BSSAP-LE message – if necessary, creating a new BSSAP-LE message if message size limitations would be exceeded. The BSC shall stop the supervision timer started in step 2 when the final segment of the final response from the MS has been transferred. If the MS did not indicate a final response in step 3, the SMLC may transfer a further RRLP message to the MS (e.g. containing assistance data) according to steps 1 and 2 and the MS may return a subsequent response according to steps 3 and 4.

8.1a Information Transfer between an SMLC and a Target MS in the PS Domain in A/Gb mode

An SMLC uses the procedure shown below in order to obtain the MS position or positioning measurements from a target MS or transfer location assistance information to a target MS in the PS domain after a request has been received from the BSS serving the target MS.

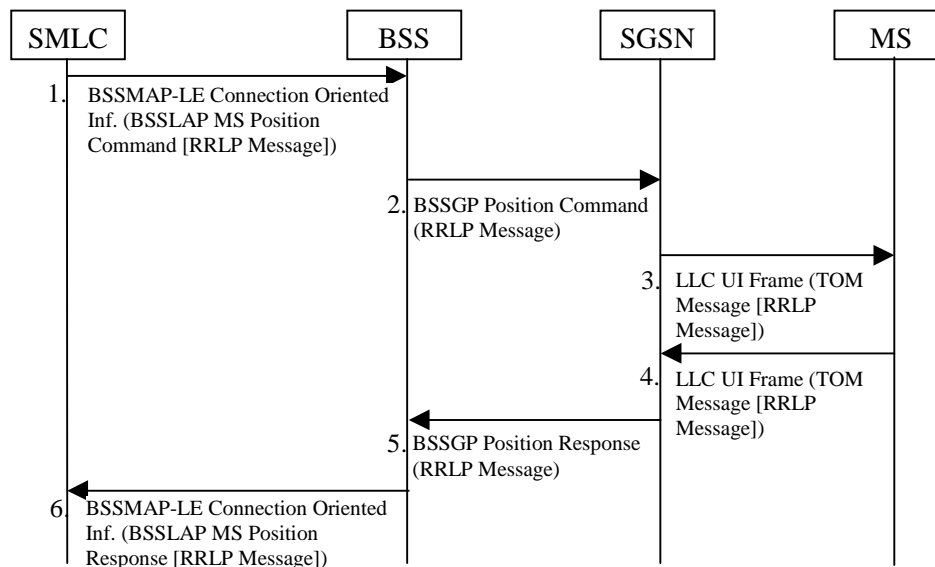


Figure 16a: Information Transfer between an SMLC and a Target MS in PS Domain

- 1) The SMLC passes a BSSAP-LE Connection Oriented Information message to the serving BSS containing an embedded BSSLAP MS Position Command with an RRLP message parameter. The message is transferred using the SCCP connection established between the SMLC and BSS for positioning the target MS. If the RRLP message is larger than the RRLP maximum PDU size, RRLP pseudo-segmentation shall be used. The SMLC shall indicate in the positioning command bit in the RRLP flags IE in the BSSLAP MS Position Command whether the embedded RRLP message contains a positioning command versus a non-command – e.g. positioning assistance data.

- 2) The BSS relays the embedded RRLP message and the RRLP flags IE to the SGSN inside a BSSGP Position Command message. When the BSSGP Position Command message has been transferred, the BSS shall start a positioning supervision timer if not already in progress or restart if the timer is already in progress. If the timer expires before the final response in step 5 is received, the BSS shall return a BSSAP-LE Connection Oriented Information message to the SMLC containing a BSSLAP Abort with a cause of BSS timeout.
- 3) The SGSN receives the RRLP message in the BSSGP Position Command message and relays it to the MS in an LLC UI frame. The TOM protocol with SAPI TOM8 is used for transfer of RRLP messages. The positioning command bit from the RRLP flags IE in the BSSGP message is also relayed using the C/R bit in the TOM header (see 3GPP TS 44.031 [15]). The received C/R bit may be ignored by the MS or used for implementation purposes.
- 4) When the target MS has positioning information to return to the SMLC, it sends an LLC UI Frame to the SGSN containing an embedded RRLP message. The TOM protocol is used for transfer of RRLP messages. If the RRLP message is larger than the RRLP maximum PDU size, RRLP pseudo-segmentation shall be used. If the RRLP pseudo-segmentation is used, the MS shall send several RRLP messages. In each message the MS shall indicate in the C/R bit in the TOM protocol header whether it is the final response or not. The final response shall be the last RRLP message that the MS expects to send in response to RRLP messages received so far from the SMLC. In the final message the MS shall indicate that it is the final response by setting the appropriate RRLP flag. For the MTA positioning method the MS does not send a RRLP message in response to the RRLP message it receives in step 3.
- 5) The SGSN relays the RRLP message to the BSS. The RRLP message is sent in a BSSGP Position Response message. The C/R bit from the TOM header is relayed using the final response bit in the RRLP flags IE in the BSSGP message.
- 6) If the timer started in step 2 has already expired, the BSS discards the RRLP message received in step 5. Otherwise, the BSS relays the RRLP message and the RRLP flags IE to the SMLC inside a BSSLAP MS Positioning Response message contained in a BSSAP-LE Connection Oriented Information message. If the SMLC indicated a positioning command in the most recent message to be transferred in step 1 and the MS has indicated a final response, the BSS may add additional measurement information to the BSSLAP MS Positioning Response in the last BSSAP-LE message. The BSS shall stop the supervision timer started in step 2 when the final response from the MS has been transferred. The SMLC may transfer a further RRLP message to the MS (e.g. containing assistance data or a positioning command) according to steps 1, 2, and 3 and the MS may return a subsequent response according to steps 4, 5, and 6. Steps 4-6 are repeated if the RRLP pseudo-segmentation is used for the uplink message.

8.1b Information Transfer between an SMLC and a Target MS in lu Mode

An SMLC uses the procedure shown below in order to obtain the MS position or positioning measurements from a target MS or transfer location assistance information to a target MS after a request has been received from the BSC serving the target MS.

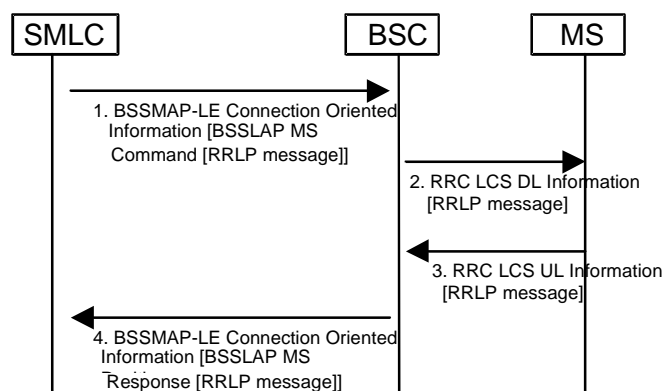


Figure 16b: Information Transfer between an SMLC and a Target MS

- 1) The SMLC passes a BSSAP-LE Connection Oriented Information message to the serving BSC containing an embedded BSSLAP MS Position Command with an RRLP message parameter. The message is transferred using the SCCP connection established between the SMLC and BSC for positioning the target MS. If the BSSLAP message is too large to fit in a single BSSAP-LE Connection Oriented Information message, RRLP pseudo-segmentation shall be used. The SMLC shall indicate in the first BSSLAP MS Position Command whether the embedded RRLP message contains a positioning command versus positioning assistance data.
- 2) The BSC transfers the embedded RRLP message to the target MS inside an RRC LCS DL Information message. No later than when the RRC LCS DL Information message has been transferred, the BSC shall start a positioning supervision timer if none is already in progress or restart this if already in progress. If the timer expires before the final response in step 3 is received, the BSC shall return a BSSAP-LE Connection oriented Information message to the SMLC containing a BSSLAP Abort with a cause of BSC timeout.
- 3) When the target MS has positioning information to return to the SMLC, it sends an RRC LCS UL Information message to the BSC containing an embedded RRLP message. If the RRLP message is too large to fit in a single RRC LCS UL Information message, RRLP pseudo-segmentation shall be used. The last RRC LCS UL Information message shall indicate if this is the final response from the MS.
- 4) If the timer started in step 2 has already expired, the BSC discards the RRLP message received in step 3. Otherwise, the BSC forwards the RRLP message to the SMLC inside a BSSLAP MS Positioning Response message contained in a BSSAP-LE Connection Oriented Information message. If the SMLC indicated a positioning command in step 1 and the MS has indicated a final response, the BSC may add additional measurement information to the BSSLAP MS Position Response in the last BSSAP-LE message – if necessary, creating a new BSSAP-LE message if message size limitations would be exceeded. The BSC shall stop the supervision timer started in step 2 when the final response from the MS has been transferred. If the MS did not indicate a final response in step 2, the SMLC may transfer a further RRLP message to the MS (e.g. containing assistance data) according to steps 1 and 2 and the MS may return a subsequent response according to steps 3 and 4.

8.2 Information Transfer between an SMLC and a BSC

An SMLC uses the procedure shown below in order to obtain positioning related information from the BSC serving a particular target MS after a positioning request has been received from the BSC. This procedure applies to positioning of an MS in both the CS and the PS domains.

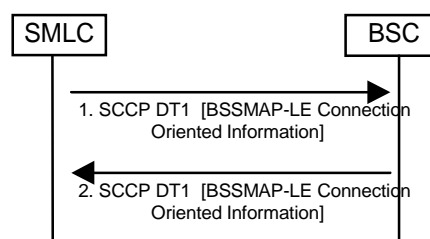


Figure 17: Information Transfer between an SMLC and a BSC

- 1) The SMLC passes a BSSAP-LE Connection Oriented Information message to the BSC containing an embedded BSSLAP message. The BSSAP-LE message is transferred using the SCCP connection previously established between the SMLC and BSC when the positioning request for the target MS was initially sent to the SMLC. The BSC recognizes that it is the final destination due to the presence of the embedded BSSLAP message.
- 2) When the BSC has positioning information for the target MS to return to the SMLC, it sends a BSSAP-LE Connection Oriented Information message to the SMLC containing an embedded BSSLAP message. The message is sent using the SCCP connection previously established for positioning the target MS. For the Multilateration based positioning methods, the BSC does not include an embedded BSSLAP message in the BSSMAP-LE Connection Oriented Information message it sends to the SMLC.

8.3 Common Procedures to Support Access to an LMU

The procedures in this clause support the transfer of positioning related information and O&M data between an SMLC and a particular LMU associated with the SMLC. These procedures apply to positioning of an MS in both the CS and the PS domains.

8.3.1 Location Update Procedure between an SMLC and a Type A LMU

The following procedure supports a normal location update from the perspective of a Type A LMU. The location update can occur periodically, on power up, following recovery from some failure condition and when an LMU in idle mode detects that its closest BTS is in another location area.

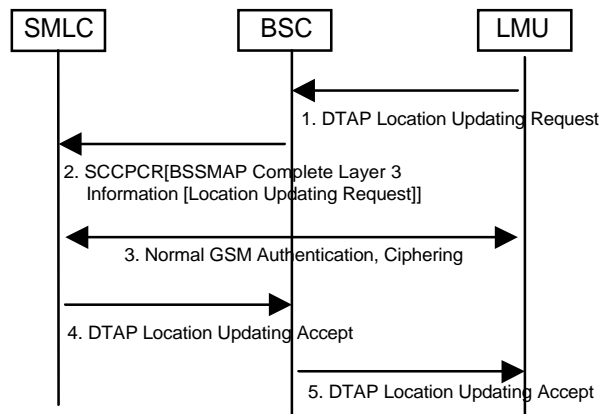


Figure 18: Location Update Procedure between an SMLC and a Type A LMU

- 1) If the LMU does not currently have a signaling link, it sends an RR Channel Request to the serving BTS to request a SDCCH. The RR Channel Request contains an establishment cause identifying an LMU. After assignment of the SDCCH, the LMU sends a DTAP Location Updating request to the BSC. This shall indicate that a follow on request is pending if the LMU has more data to send.
- 2) Because the BSC serving the LMU is associated with an SMLC and the Channel Request message contained an LMU establishment cause, the BSC forwards the Location Updating request to the SMLC rather than MSC. If there was previously no SDCCH, this is sent inside a BSSMAP Complete Layer 3 Information message that is contained in an SCCP Connection Request.
- 3) The SMLC performs normal authentication and ciphering if needed for the LMU. The SMLC shall not assign a TMSI to the LMU to avoid duplicating a TMSI assigned to a normal MS by a VLR.
- 4) The SMLC returns a DTAP Location Updating Accept to the BSC. Unless the LMU indicated a follow on request, the SMLC may then initiate release of the SDCCH.
- 5) The BSC forwards the DTAP message to the LMU.

8.3.2 IMSI Detach Procedure between an SMLC and a Type A LMU

The following procedure supports a normal IMSI Detach from the perspective of a Type A LMU. This may be instigated if the LMU is to be deactivated – e.g. for offline maintenance.

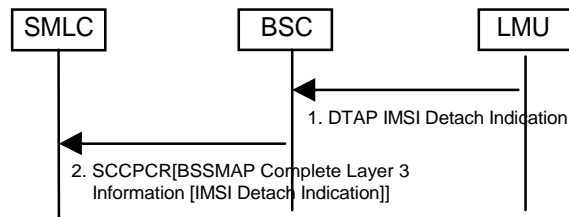


Figure 19: IMSI Detach Procedure between an SMLC and a TypeA LMU

- 1) If the LMU does not currently have a signaling link, it sends an RR Channel Request to the serving BTS to request a SDCCH. The RR Channel Request contains an establishment cause identifying an LMU. After assignment of the SDCCH, the LMU sends a DTAP IMSI Detach Indication to the BSC.
- 2) Because the BSC serving the LMU is associated with an SMLC and the Channel Request message contained an LMU establishment cause, the BSC forwards the IMSI Detach Indication to the SMLC rather than MSC. If there was previously no SDCCH, this is sent inside a BSSAP Complete Layer 3 Information message that is contained in an SCCP Connection Request. The SMLC marks the LMU as temporarily inactive and initiates release of the SDCCH.

8.3.3 LCS Information Transfer between an SMLC and a Type A LMU

8.3.3.1 Information Transfer using an SDCCH

The following procedure supports information transfer between an SMLC and a Type A LMU.

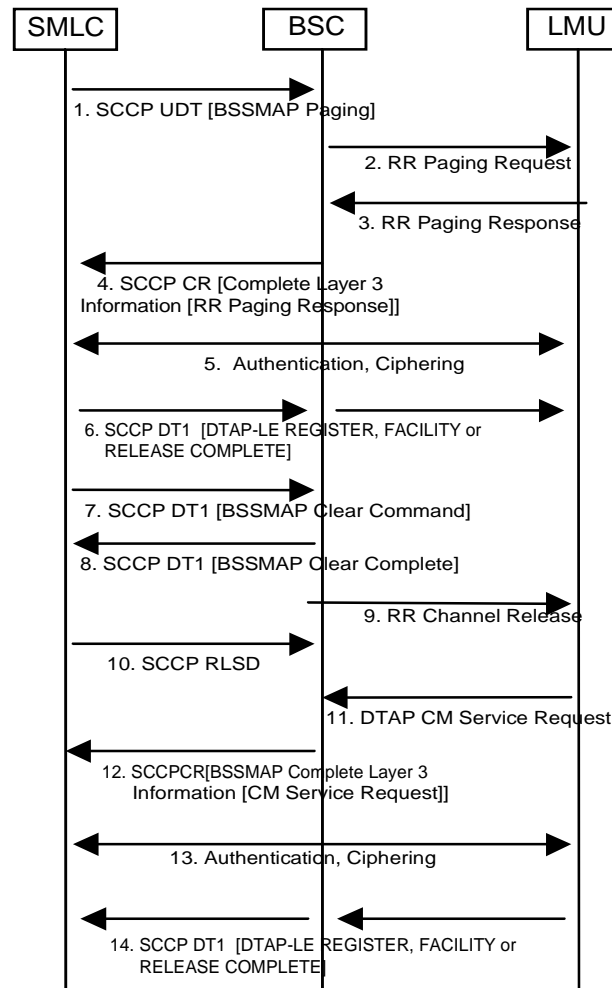


Figure 20: Information Transfer between an SMLC and a Type A LMU

- 1) If there is no signaling link yet for an LMU between the SMLC and the BSC serving the LMU, the SMLC sends a BSSAP Paging message to the serving BSC inside an SCCP Unitdata message.
- 2) The serving BSC broadcasts an RR Paging Request.
- 3) The LMU sends a Channel Request message containing an LMU establishment cause to request an SDCCH. After assignment of the SDCCH, the LMU returns an RR Paging Response.
- 4) Because the BSC serving the LMU is associated with an SMLC and the Channel Request message in step 3 contained an LMU establishment cause, the BSC transfers the Paging Response to the SMLC, rather than MSC, in a BSSAP Complete Layer 3 Information message contained in an SCCP Connection Request.
- 5) The SMLC performs normal authentication and ciphering if this is needed for the LMU. The SMLC shall not assign a TMSI to the LMU to avoid duplicating a TMSI assigned to a normal MS by a VLR.
- 6) If the SMLC needs to send data to the LMU, it may send one or more DTAP-LE REGISTER, FACILITY or RELEASE COMPLETE messages to the BSC. Each DTAP-LE message contains an embedded LLP message and an indication of whether release of the SDCCH by the LMU is forbidden. Each DTAP-LE message is transferred by the BSC to the LMU.

- 7) The SMLC may initiate release of the SDCCH to the LMU by sending a BSSAP Clear Command to the BSC.
- 8) The BSC returns a BSSAP Clear Complete.
- 9) The BSC orders release of the SDCCH by sending an RR Channel Release to the LMU.
- 10) The SMLC releases the SCCP connection to the BSC by sending an SCCP Released message.
- 11) When the LMU has LCS data to send and does not currently have a signaling link, it sends an RR Channel Request to the serving BTS to request an SDCCH. The RR Channel Request contains an establishment cause identifying an LMU. After assignment of the SDCCH, the LMU sends a DTAP CM Service request to the serving BSC.
- 12) Because the BSC serving the LMU is associated with an SMLC and the Channel Request message contained an LMU establishment cause, the BSC forwards the CM Service Request with an indication that this came from an LMU to the SMLC, rather than MSC, inside a BSSAP Complete Layer 3 Information message that is contained in an SCCP Connection Request.
- 13) The SMLC performs authentication and ciphering if needed for the LMU. Otherwise, a CM Service Accept is returned. The SMLC shall not assign a TMSI to the LMU to avoid duplicating a TMSI assigned to a normal MS by a VLR.
- 14) The LMU sends one or more DTAP-LE REGISTER, FACILITY or RELEASE COMPLETE messages to the serving BSC each containing an embedded LLP message. The BSC forwards each DTAP-LE message to the SMLC.

8.3.3.2 Information Transfer using a TCH

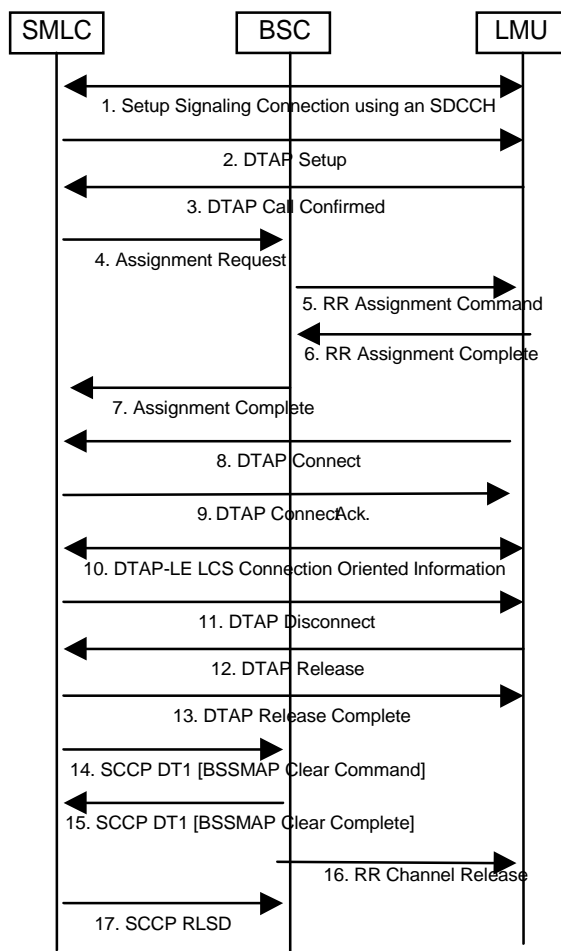


Figure 21: Information Transfer between an SMLC and a Type A LMU using a TCH

- 1) The SMLC establishes a signaling connection to the LMU using an SDCCH.
- 2) The SMLC sends a DTAP Setup to the LMU with the requested bearer capability.
- 3) The LMU returns a DTAP Call Confirmed.
- 4) The SMLC initiates traffic channel assignment by sending a BSSAP Assignment Request to the BSC.
- 5) The BSC requests channel activation in the BTS and then sends an RR Assignment Command to the LMU.
- 6) The LMU acknowledges TCH assignment.
- 7) The BSC confirms TCH assignment.
- 8) The LMU confirms call establishment.
- 9) The SMLC acknowledges the LMU confirm.
- 10) DTAP-LE Connection Oriented Information messages are transferred between the SMLC and LMU on the established TCH: these are transparent to the BSC.
- 11) The SMLC initiates release of the TCH by sending a DTAP Disconnect to the LMU
- 12) The LMU returns a DTAP Release.
- 13) The SMLC sends a DTAP Release Complete.
- 14) The SMLC initiates release of the TCH by sending a BSSAP Clear Command to the BSC.
- 15) The BSC returns a BSSAP Clear Complete.
- 16) The BSC orders release of the TCH by sending an RR Channel Release to the LMU.
- 17) The SMLC releases the SCCP connection to the BSC by sending an SCCP Released message.

8.3.4 LCS Information Transfer between an SMLC and a Type B LMU

A SMLC uses the procedure shown below in order to exchange LCS information with a TypeB LMU.

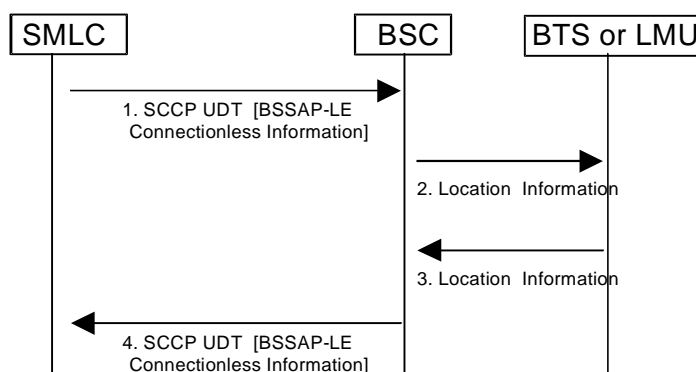


Figure 22: Information Transfer between a SMLC and a Type B LMU

- 1) The SMLC passes a BSSAP-LE Connectionless Information message to the BSC containing an embedded LLP message and the LAC/CI cell address identifying the LMU. The BSSAP-LE message is transferred inside an SCCP Unitdata message.
- 2) The BSC transfers the embedded LLP message to either the BTS associated with the LMU or the LMU itself inside a Location Information message. The BTS or LMU is identified using the LAC/CI received in step 1.
- 3) When the LMU has positioning information to return to the SMLC, either it or its associated BTS transfers this to the BSC inside a Location Information message..

- 4) The serving BSC forwards the LLP message to the SMLC inside a BSSAP-LE Connectionless Information message contained in an SCCP Unitdata message. The BSSAP-LE message contains the LAC/CI address identifying the LMU.

8.4 Common Control Procedures for LMUs

These procedures are applicable to any Type A LMU and may be used for any Type B LMU to enable control of the LMU by its associated SMLC. The procedures assume support for the establishment of a signaling link and the transfer of LLP messages between an SMLC and LMU that are defined in the common procedures to support access to an LMU, clause 8.3. Consequently, details of signaling link establishment and message transfer by a BSC and BTS are not shown.

8.4.1 Reset Procedure

The reset procedure enables an SMLC to return an LMU to a known initial state in which no measurement or O&M operations are outstanding or being performed.

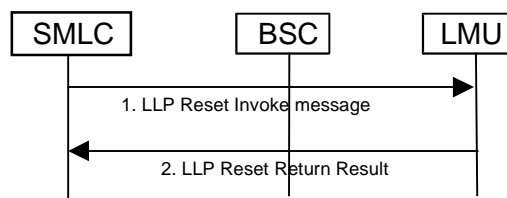


Figure 23: Reset Procedure for a Circuit Mode LMU

- 1) After first establishing a signaling connection to the LMU (see clause 8.3), the SMLC sends an LLP Reset Invoke to the LMU via BSC.
- 2) The LMU cancels any LCS measurement and O&M tasks previously ordered by the SMLC. The LMU then returns an LLP Reset Return Result to the SMLC.

8.4.2 Status Query Procedure

The Status Query procedure enables an SMLC to verify the status of an associated LMU. The procedure may be instigated periodically or following any loss of communication with the LMU.

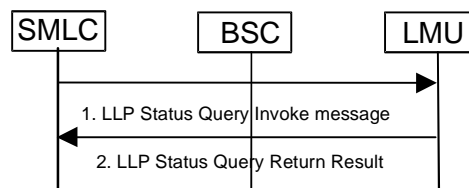


Figure 24: Status Query Procedure for a Circuit Mode LMU

- 1) After first establishing a signaling connection to the LMU (see clause 8.3), the SMLC sends an LLP Status Query Invoke to the LMU via BSC.
- 2) The LMU returns an LLP Status Query return result, indicating the number of active measurement jobs for each type of measurement (e.g. RIT) and the number of active O&M jobs in the LMU that were previously ordered by the SMLC.

8.4.3 Status Update Procedure

The Status Update procedure enables an LMU to report status information to its associated SMLC. The procedure may be instigated for the following reasons:

1. Periodically;
2. Power-on condition or recovery from failure with loss of memory;
3. Impending availability or unavailability for O&M reasons;
4. Location Update by a Type A LMU in a new Location Area.

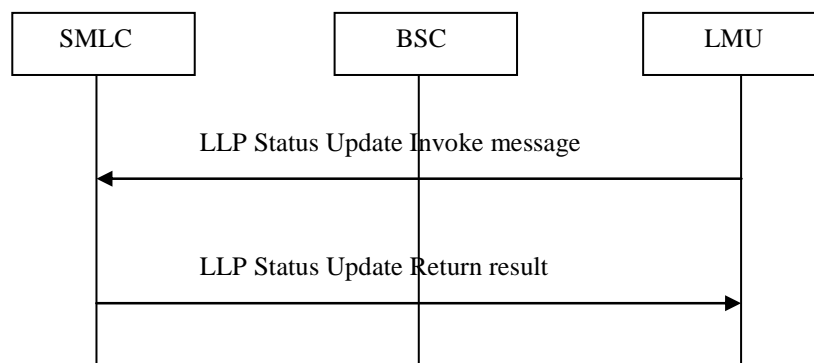


Figure 25: Status Update Procedure for a Circuit Mode LMU

- 1) After first establishing a signaling connection to the SMLC (see clause 8.3), the LMU sends an LLP Status Update Invoke to the SMLC via BSC. This message shall include the reason for the Status Update, the number of active and outstanding jobs of each category in the LMU and the current hardware status.
- 2) The SMLC returns an LLP Status Update return result to acknowledge receipt of the Status Update.

8.5 Exception Procedures

The procedures in this clause apply to all location procedures where a BSSAP-LE Perform Location Request has been sent to an SMLC by a BSC requesting some location service (e.g. provision of a location estimate for a target MS or transfer of assistance data to a target MS).

8.5.1 Procedures in the SMLC

When a request for a location estimate fails due to failure of a position method itself (e.g. due to inaccurate or insufficient position measurements and related data) and the SMLC is unable to instigate another positioning attempt (e.g. due to a requirement on response time), the SMLC may return a BSSAP-LE Perform Location response containing a less accurate location estimate (e.g. based on serving cell and timing advance). If a less accurate estimate is not available, the SMLC shall instead return a BSSAP-LE Perform Location response message containing no location estimate and indicating the cause of failure.

When a request for any other location service (e.g. transfer of assistance data to a target MS) fails for any reason and the SMLC is unable to reattempt the service, the SMLC shall return a BSSAP-LE Perform Location response message indicating the cause of failure.

When a location service request is interrupted by some other unrecoverable error event inside the SMLC, the SMLC shall immediately terminate the location service attempt and return a BSSAP-LE Perform Location Response message containing the reason for the location service cancellation. In that case, any dialogue previously opened with an LMU or BSS for the purpose of instigating position measurements for any MS being located may also be aborted by the SMLC.

If the SMLC receives a BSSAP-LE Perform Location Abort indication for a previous location service request from the BSS, it shall immediately terminate the location service attempt and may abort any dialogues used for the location service attempt that may still exist with any LMUs. The circumstances of the abort may still ensure cancellation of any such procedure (see clause on BSS). For a BSSAP-LE Perform Location Abort, the SMLC shall then either return any location estimate (with optional velocity estimate) already derived, if this was requested, or return a BSSAP-LE Perform Location response indicating failure of the location service and the cause of the failure in the BSSAP-LE Perform Location Abort.

If the SMLC has instigated any location related procedure in the Target MS or its serving BSS and receives a BSSLAP Reject, BSSLAP Abort or BSSLAP Reset indication from the BSS, it shall cancel the location service attempt and may abort any dialogues for this that currently exist with any LMUs. For a BSSLAP Abort, the SMLC shall then either return any location estimate (with optional velocity estimate) already derived, if this was requested and is sufficient for the requested QoS, or return a BSSAP-LE Perform Location response indicating failure of the location service and the cause of the failure in the BSSLAP Abort. For a BSSLAP Reject and BSSLAP Reset, the SMLC has the additional option of restarting the location service attempt and using the same or a different position method where a location estimate was requested. A decision to restart the location service shall take into account the cause of the location service failure as conveyed in the BSSLAP Reject or BSSLAP Reset and whether, in the case of successful intra-BSC handover, the new cell for the target MS is still associated with the SMLC. If the SMLC receives a BSSLAP Reject or BSSLAP Reset with a cause indicating intra-BSC handover and with a new cell identity for the target MS that is not associated with the SMLC, the SMLC shall return a BSSAP-LE Perform Location response containing either a location estimate (with optional velocity estimate), if requested and available, or a failure cause indicating "intra-BSC" handover.

NOTE: In the CS domain, in the case of an intra-BSC handover to a cell in a different PLMN (different MCC, MNC combination), the SMLC may receive a BSSLAP Reset containing the new location area code and new cell ID. The SMLC may then deduce the new MCC and MNC from the uniqueness, when this applies, of the combined values for the new location area code and cell ID compared to the corresponding values for neighbouring cells.

8.5.2 Procedures in an LMU

An LMU shall return an error indication to its controlling SMLC when location measurements previously ordered by the SMLC cannot be provided due to any error condition.

8.5.3 Procedures in the BSC in the CS Domain

8.5.3.1 General Procedures

The BSC serving a target MS shall supervise any network or MS location service procedure, including transfer of positioning assistance data to an MS, and shall only allow one such procedure to be active at any time. If a new procedure is instigated by the SMLC for any target MS, the BSC shall cancel any previous procedure without notifying the SMLC or target MS. The new procedure shall then be treated according to the prevailing conditions. If a location information transfer to an MS initiated by an SMLC is not active, the BSC shall discard any RRLP message received from the MS. This precludes the initiation of any location service procedure from an MS.

The BSC may optionally allow one A-GNSS or E-OTD positioning procedure and one Cell-based or U-TDOA positioning procedure to be active concurrently for the same target MS. The BSC shall indicate the second independent location procedure is supported when SMLC instigates a first positioning procedure for any MS. The SMLC may initiate the concurrent positioning procedure only in when the BSC has indicated this capability. The BSC may disallow the concurrent positioning procedure at any time.

In the concurrent positioning procedure, if the SMLC invokes a first A-GNSS or E-OTD location procedure and then invokes a second A-GNSS or E-OTD then the BSC shall cancel the first procedure and proceed with the second without notifying the SMLC or target MS. In the concurrent location procedure, if the SMLC invokes a first cell-based or U-TDOA location procedure and then invokes a second cell-based or U-TDOA location procedure then the BSC shall cancel the first procedure and proceed with the second positioning procedure without notifying the SMLC or target MS.

Depending on the location procedure and its current state of execution, a serving BSC may chose to defer certain radio related events (e.g. handover) to avoid interference with location – refer to the later clauses for each positioning procedure. A serving BSC shall abort all existing location related procedures for a particular target MS without

notifying a target MS if the DCCH to the target MS or the SCCP connection to the SMLC is released. In the event of an abort with an SMLC, the BSC shall attempt to notify the SMLC using a BSSAP-LE Perform Location Abort.

8.5.3.2 Rejection of an SMLC Positioning Request

The BSC may reject any request from an SMLC for positioning or transfer of assistance data for a target MS if the request cannot be performed for reasons other than interaction with handover or other RR management. If the request is rejected, the BSC shall return a BSSLAP Reject to the SMLC containing the cause of rejection.

8.5.3.3 Interaction with Inter-BSC Handover

The BSC shall reject any request from an SMLC for positioning or transfer of assistance data while an inter-BSC handover procedure is ongoing and shall return a BSSLAP Abort to the SMLC.

The BSC shall terminate any network or MS positioning procedure or any transfer of RRLP assistance data already in progress if inter-BSC handover is needed and is not precluded by the particular location procedure and its current state. When a location procedure is terminated and there is an active BSSLAP transaction, the BSC shall return a BSSLAP Abort message to the SMLC after the BSSAP Handover Required has been sent to the serving MSC. The BSSLAP Abort shall contain the cause of the location procedure failure. When a location procedure is terminated and there is no active BSSLAP transaction, the BSC shall send a BSSAP-LE Perform Location Abort message to the SMLC after the BSSMAP Handover Required has been sent to the serving MSC.

8.5.3.4 Interaction with Intra-BSC Handover and other RR Management Procedures

The BSC shall reject any request from an SMLC for positioning or transfer of assistance data while an intra-BSC handover or other intra-BSC RR management procedure involving the target MS is ongoing and shall return a BSSLAP Reset to the SMLC when the handover or other RR management procedure is complete in the BSC. If the handover or other RR management procedure times out in the BSC, the BSC shall instead return either a BSSLAP Reset or a BSSLAP Abort to the SMLC.

The BSC shall terminate any network or MS positioning procedure or any transfer of RRLP assistance data already in progress if an intra-BSC handover or other intra-BSC RR management procedure is needed and is not precluded by the particular location procedure and its current state. When location procedure is terminated, the BSC shall return a BSSLAP Reset message to the SMLC after the intra-BSC handover or other RR management procedure is complete in the BSC. If the intra-BSC handover or other RR management procedure times out in the BSC, the BSC shall instead return either a BSSLAP Reset or a BSSLAP Abort to the SMLC.

A BSSLAP Reset shall contain a cause indication, the current serving cell identity, the current location area code if this has just changed due to intra-BSC handover and may contain measurement information for the target MS (e.g. TA value). A BSSLAP Reset shall also include the current location area code if there has been any change of location area since the location request for the target MS was first sent to the SMLC and if the current location area code was not yet reported to the SMLC in a previous BSSLAP Reset.

8.5.3.5 Priority of Handover and Other RR Management Procedures

If the transfer of RRLP messages between an SMLC and target MS is interrupted by intra-BSC handover, inter-BSC handover or any other intra-BSC RR management procedure, the BSC shall avoid delay to the handover or RR management procedure by employing the preemption capability defined in 3GPP TS 44.006 and 3GPP TS 24.008. This allows an RR Handover Command or other RR management command sent to the target MS to be assigned a "high" priority at the data link level enabling preemption of "low" priority RR Application Information messages (carrying RRLP messages) which may have been sent earlier. This procedure ensures that any RRLP data still not transmitted to the MS will be preempted (and discarded) by the data link layer in the BTS prior to transmission of the Handover Command or other RR Management command.

8.5.3.6 Interaction with Segmentation support for Legacy MS

If a location information transfer to an MS initiated by an SMLC is not active, the BSC shall discard any RRLP message segment received from the MS. Once a location service procedure has been started involving RRLP message transfer to a target MS, the BSC shall discard all RRLP segments received from the MS until it receives the first or only segment of a new RRLP message. The new RRLP message shall then be treated according to the state of the RRLP message transfer as described in clause 8.1.

Further details regarding transfer and segmentation of RRLP messages between a BSC and MS can be found in 3GPP TS 44.018.

8.5.3.7 Overload

The BSC may indicate an inability to support location due to overload by rejecting with a cause indicating congestion a BSSAP Perform Location request received from the MSC. If an SMLC has rejected a request from the BSC to perform location with a cause indicating congestion, the BSC shall convey the rejection and cause to the MSC if the request was MSC initiated. If the request was initiated by the BSC, the BSC may reduce the frequency of its location requests to the SMLC according to the rules in 3GPP TS 49.031, which give precedence to location service requests with a higher priority.

8.5.4 Procedures in the BSS in the PS Domain

8.5.4.1 General Procedures

The BSS serving a target MS shall supervise any network or MS location service procedure, including transfer of positioning assistance data to an MS, and shall only allow one such procedure to be active at any time for any one TLLI. If a new procedure is instigated by the SMLC for any target MS, the BSS shall cancel any previous procedure without notifying the SMLC or target MS. The new procedure shall then be treated according to the prevailing conditions. If a location information transfer to an MS initiated by an SMLC is not active, the BSS shall discard any RRLP message received from the MS via the SGSN.

The BSC may optionally allow one A-GNSS or E-OTD positioning procedure and one Cell-based or U-TDOA positioning procedure to be active concurrently for the same target MS. The BSC shall indicate the second independent location procedure is supported when SMLC instigates a first positioning procedure for any MS. The SMLC may initiate the concurrent positioning procedure only in when the BSC has indicated this capability. The BSC may disallow the concurrent positioning procedure at any time.

In the concurrent positioning procedure, if the SMLC invokes a first A-GNSS or E-OTD location procedure and then invokes a second A-GNSS or E-OTD then the BSC shall cancel the first procedure and proceed with the second without notifying the SMLC or target MS. In the concurrent location procedure, if the SMLC invokes a first cell-based or U-TDOA location procedure and then invokes a second cell-based or U-TDOA location procedure then the BSC shall cancel the first procedure and proceed with the second positioning procedure without notifying the SMLC or target MS.

A serving BSS shall abort all existing location related procedures for a particular target MS without notifying a target MS if the SCCP connection to the SMLC is released. In the event of an abort when no BSSLAP procedure is active, but a location procedure is active, the BSS shall attempt to notify the SMLC using a BSSAP-LE Perform Location Abort.

A serving BSS shall abort all existing location related procedures for a particular target MS if the radio connection to the MS is lost. The SMLC shall be notified with a BSSAP-LE Perform Location Abort if no BSSLAP procedure is currently active. If there is an active BSSLAP procedure, the BSSLAP Abort message shall be sent to the SMLC.

A serving BSS shall return a BSSLAP Reject to the SMLC containing the cause of rejection, if the BSS receives the BSSGP Position Response message from the SGSN indicating a failure.

8.5.4.2 Rejection of an SMLC Positioning Request

The BSS may reject any request from an SMLC for positioning or transfer of assistance data for a target MS if the request cannot be performed. If the request is rejected, the BSS shall return a BSSLAP Reject to the SMLC containing the cause of rejection.

8.5.4.3 Overload

The BSS may indicate an inability to support location due to overload by rejecting with a cause indicating congestion sent in a BSSGP Perform Location Response message to the SGSN. If an SMLC has rejected a request from the BSS to perform location with a cause indicating congestion, the BSS shall convey the rejection and cause to the SGSN if the request was initiated by the SGSN. If the request was initiated by the BSS, the BSS may reduce the frequency of its location requests to the SMLC according to the rules in 3GPP TS 49.031, which give precedence to location service requests with a higher priority.

8.5.4.4 Inter BSS Cell Change

If the BSS detects (e.g. when it receives a BSSGP-FLUSH-LL PDU from the SGSN) that a target MS has changed cell to another BSS, it shall abort the positioning procedure by sending the BSSAP-LE Perform Location Abort to the SMLC.

8.5.5 Void

8.6 Procedures in the Target MS

A target MS shall terminate any positioning procedure or the transfer of RRLP positioning assistance data without sending any response to the SMLC if any RR message is received from the BSC that starts some other RR management procedure, including a new positioning procedure. The new RR procedure shall then be executed by the MS.

A target MS shall terminate any positioning procedure or the transfer of RRLP positioning assistance data without sending any response to the SMLC if a Routing Area Update Request message is sent to the SGSN or if a suspension request message is sent to the network or if its P-TMSI is reallocated.

8.7 Further Procedures for Handover

Handover procedures are described in 3GPP TS 23.271 [7].

9 Positioning procedures

The following clause describes the positioning procedures for Timing Advance, Enhanced Observed Time Difference and A-GNSS.

9.1 Positioning Procedure Initiation

9.1.1 Core Network Position Procedure Initiation over the A interface

This procedure is used by the Core Network to start the positioning procedure in GERAN over the A interface.

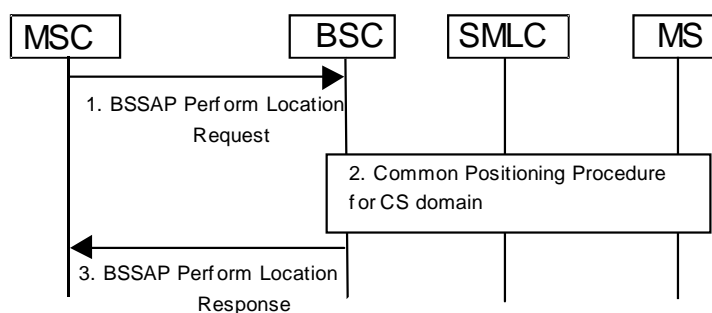


Figure 26: Positioning Procedure Initiation Over A Interface

- 1) The MSC sends the BSSAP Perform Location Request message on the existing SCCP connection for the target MS to request the BSC to start the positioning procedure. The Location Type is always included. Depending on the type of location request, additional parameters may be included to provide the Cell Identifier, Classmark Information Type 3, LCS Client Type, Chosen Channel, LCS Priority, Quality of service, A-GNSS Assistance Data, and APDU. In addition, the IMSI and / or the IMEI of the mobile station involved in the positioning procedure may be provided by the MSC in order, if forwarded by the BSC, to allow the SMLC to maintain a context between subsequent requests for a mobile station, to tune positioning for each mobile station and to add more options for SMLC diagnostics.

- 2) The common positioning procedures for CS domain are executed (see below).
- 3) The BSC sends the BSSAP Perform Location Response message to the MSC. A location estimate, velocity estimate, positioning data, deciphering keys, or LCS Cause may be included.

9.1.2 Positioning Procedure Initiation from an Internal LCS Client for the CS Domain (A/Gb mode)

Figure 27 illustrates how a serving BSC may obtain the location of a target MS that is already in dedicated mode on behalf of some PLMN operator LCS client in GERAN – e.g. to support handover. The procedure is valid when local regulatory requirements do not require privacy checking for PLMN operator initiated location.

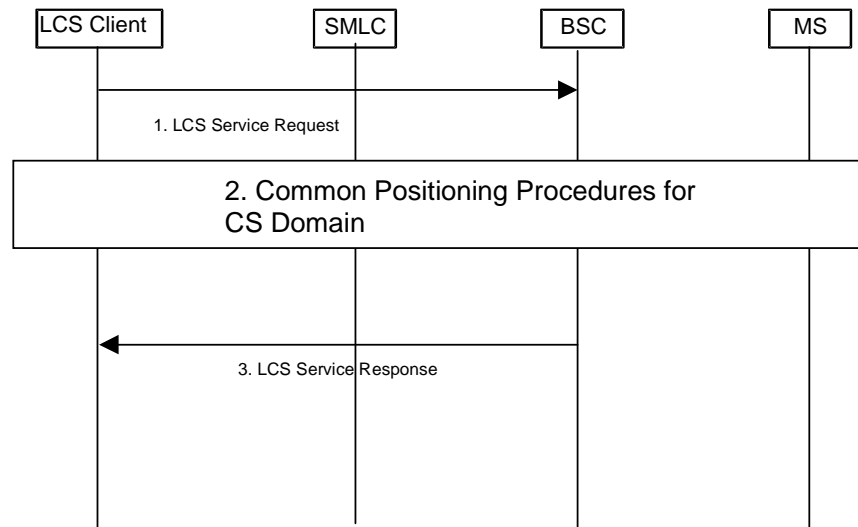


Figure 27: Positioning Procedure Initiation from an Internal LCS Client

- 1) An LCS client within the GERAN requests the current location of a target MS from the serving BSC
- 2) The common positioning procedures for CS domain are executed see Figure 28. The BSC returns the MS location estimate to the requesting LCS client.

9.1.3 Core Network Position Procedure Initiation over the Gb interface

This procedure is used by the Core Network to start the positioning procedure in GERAN over the Gb interface except for the Multilateration positioning methods (i.e. MTA and MOTD, treated in subclause 9.1.3a and is shown in Figure 27a-1).

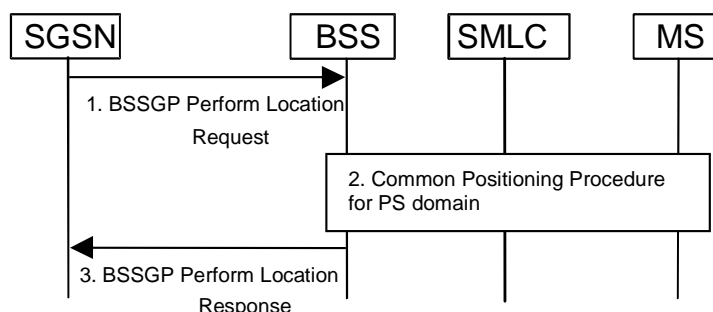


Figure 27a: Positioning Procedure Initiation over Gb Interface

- 1) The SGSN sends the BSSGP Perform Location Request message to request the BSS to start the positioning procedure. The TLLI, IMSI, DRX Parameters or eDRX Parameters, Current BVCI for the MS, Current NSEI for

the MS, Location Type, Current Cell Identifier, and LCS Capability IEs are always included. The SGSN may also include the Coverage Class and MS Radio Access Capability IEs for a MS that supports EC-GSM-IoT (see 3GPP TS 43.064). The IMSI, DRX Parameters or eDRX Parameters, Current BVCI for the MS, Current NSEI for the MS and optionally the Coverage Class and MS Radio Access Capability shall be stored in the SCCP signalling context towards the SMLC for potential use in a TA Request procedure later on. Depending on the type of location request, additional parameters may be included in the BSSGP Perform Location Request message to provide LCS Client Type, LCS Priority, LCS Quality of Service, and A-GNSS Assistance Data. In addition, the IMEI of the mobile station involved in the positioning procedure may be provided by the SGSN. The IMSI and, if forwarded by the BSS, the IMEI, would allow the SMLC to maintain a context between subsequent requests for a mobile station, to tune positioning for each mobile station and to add more options for SMLC diagnostics.

- 2) The common positioning procedures for PS domain are executed (see clause 9.2a).
- 3) The BSS sends the BSSGP Perform Location Response message to the SGSN. The TLLI and the BVCI identifying the cell from which the last LLC PDU was received from the MS are always included. A location estimate, velocity estimate, positioning data, deciphering keys, or LCS Cause may be included.

9.1.3a Core Network Position Procedure Initiation over the Gb interface for Multilateration Positioning methods

This procedure is used by the Core Network to start the Multilateration positioning methods in GERAN over the Gb interface (i.e. MTA and MOTD). The signalling flow applies for an MS in Packet Idle mode only and is shown in Figure 27a-1. When the serving cell of an MS is known the Multilateration positioning method in GERAN is triggered by the Perform Location Request message sent from SGSN to BSS as depicted in clause 9.6.

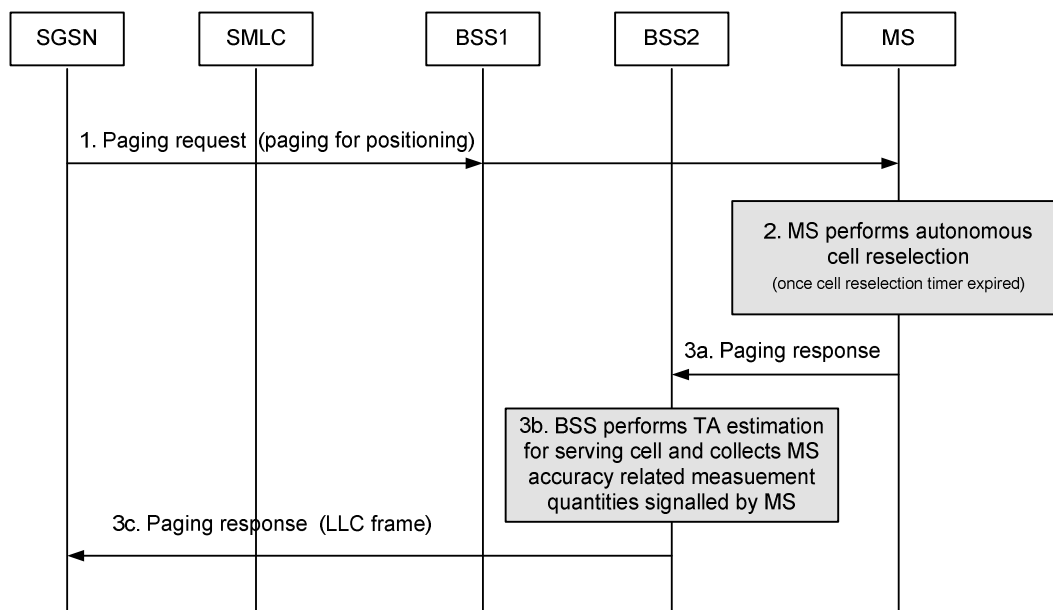


Figure 27a-1: Positioning Procedure Initiation over Gb Interface for Multilateration Positioning

If the MS is in Packet Idle mode (i.e. Ready timer is not running) the following procedure is executed.

- 1) Upon receiving a position request from a GMLC, the SGSN sends a paging request message to each BSS supporting paging for positioning in the set of BSS managing cells in the paging area corresponding to the target MS and indicates in the paging request that a positioning event has triggered the paging, i.e. it sends a paging request for positioning.
- 2) This triggers the MS to start the cell re-selection procedure unless a cell re-selection has been performed up to [60] seconds prior to receiving the paging request message indicating that the paging is triggered by a positioning event. The MS then reselects to the “best” cell.

- 3) The MS sends a paging response to the SGSN, which may occur in the serving cell or in the new cell in case of cell reselection. Due to the interim cell reselection procedure the paging response may be received from another BSS (i.e. BSS 2) than the BSS (i.e. BSS 1) the paging request indicating the positioning cause was sent to.
 - a) In the paging response the MS includes MS accuracy related information (“MS Sync Accuracy”, “MS Transmission Offset”) on the RR layer (see 3GPP TS 44.060 [28]).
 - b) The BSS estimates the timing advance (i.e. a value used as the “Multilateration Timing Advance”), including a compensation using the reported “MS Transmission Offset”, as well as calculates the BTS Reception Accuracy Level (see 3GPP TS 45.010 [42]), applicable to the serving cell when the MS sends the paging response.
 - c) The BSS sends the paging response including “Multilateration Timing Advance”, “MS Sync Accuracy” and “BTS Reception Accuracy Level” in an UL-UNITDATA PDU to the SGSN.

Upon receiving the paging response from the BSS, the SGSN, includes the “Multilateration Timing Advance”, “MS Sync Accuracy” and “BTS Reception Accuracy Level” sends a BSSGP PERFORM-LOCATION-REQUEST to the BSS, managing the serving cell and follows the MTA or MOTD method related procedure as described in sub-clause 9.6.

9.1.4 Positioning Procedure Initiation from Core Network (Iu mode)

This procedure is used by the Core Network to start the positioning procedure in GERAN Iu mode. This procedure is used when the source node in the Core Network is the 3G-MSC (Iu-cs interface) or when the source node in the Core Network is the 3G-SGSN (Iu-ps interface).

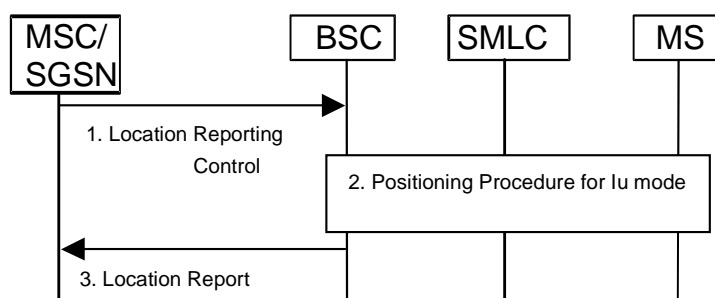


Figure 27b: Positioning Procedure Initiation from Core Network (Iu mode)

- 1) The MSC/SGSN sends the Location Reporting Control message on the existing SCCP connection for the target MS to request the BSC to start the positioning procedure. The Location Type is always included. Depending on the type of location request, additional parameters may be included to provide LCS Client Type, LCS Priority, Quality of service, and A-GNSS Assistance Data.
- 2) The Positioning Procedure for Iu mode is executed (see below).
- 3) The BSC sends the Location Report message to the MSC/SGSN. A location estimate (with optional velocity estimate), or LCS Cause may be included.

9.1.5 Positioning Procedure Initiation from Internal LCS Client (Iu mode)

FFS.

9.2 Common Positioning Procedure for CS Domain in A/Gb mode

This procedure is common to all positioning methods in the CS domain.

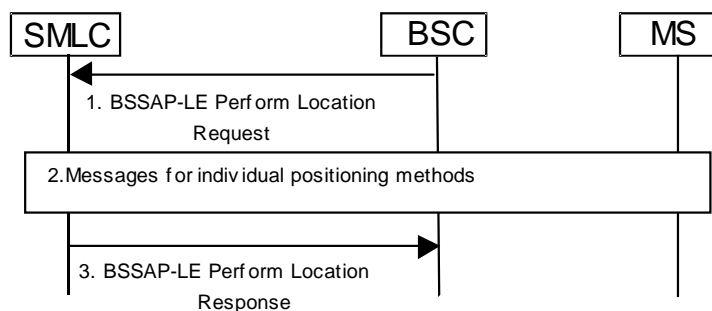


Figure 28: Common Positioning Procedure for CS Domain

- 1) The BSC sends the BSSAP-LE Perform Location Request message to request the SMLC to start the positioning procedure. The Location Type and Current Cell Identifier IEs are always included. Depending on the type of location request, additional parameters may be included to provide Measurement Report (in BSSLAP APDU IE), LCS Client Type, Classmark Information Type 3, Chosen Channel, LCS Priority, LCS Quality of Service, and A-GNSS Assistance Data. In addition, the IMSI and / or the IMEI of the mobile station involved in the positioning procedure may be provided by the BSC in order to allow the SMLC to maintain a context between subsequent requests for a mobile station, to tune positioning for each mobile station and to add more options for SMLC diagnostics.
- 2) If location information is requested and the location accuracy within the QoS, if provided, can be satisfied by the reported cell ID and, if available, TA value, the SMLC may send a BSSAP-LE Perform Location Response message immediately. Otherwise, the SMLC determines the positioning method and instigates the particular message sequence for this method defined in subsequent clauses. If the position method returns position measurements, the SMLC uses them to compute a location estimate (with optional velocity estimate). If there has been a failure to obtain position measurements, the SMLC may use the current cell ID and, if available, TA value to derive an approximate location estimate. If a computed location estimate is returned for an MS based position method, the SMLC may verify consistency with the current cell ID and, if available, TA value. If the location estimate so obtained does not satisfy the requested accuracy or the location attempt failed, e.g. due to missing data, and sufficient response time still remains, the SMLC may instigate a further location attempt using the same (e.g. providing more assistance data to MS) or a different position method. If there is insufficient response time for another position attempt, the SMLC shall return any location estimate already obtained even if not satisfying the requested accuracy. If a vertical location co-ordinate is requested but the SMLC can only obtain horizontal co-ordinates, these may be returned. Requirements on the geographic shape encoded within the 'position information' parameter may exist for certain LCS client types. The SMLC shall comply with any shape requirements defined in 3GPP. The SMLC in a certain country should attempt to comply with the shape requirements defined for a specific LCS client type in the relevant national standards of that country. If location assistance data is requested, the SMLC transfers this data to the MS as described in subsequent clauses. The SMLC determines the exact location assistance data to transfer according to the type of data specified by the MS, the MS location capabilities and the current cell ID. If deciphering keys are requested the SMLC obtains the current keys.
- 3) The SMLC sends the BSSAP-LE Perform Location Response message to the BSC containing any location estimate (with optional velocity estimate) or deciphering keys. In case of failure the cause value may be included.

9.2a Common Positioning Procedure for PS Domain in A/Gb mode

This procedure is common to all positioning methods in the PS domain.

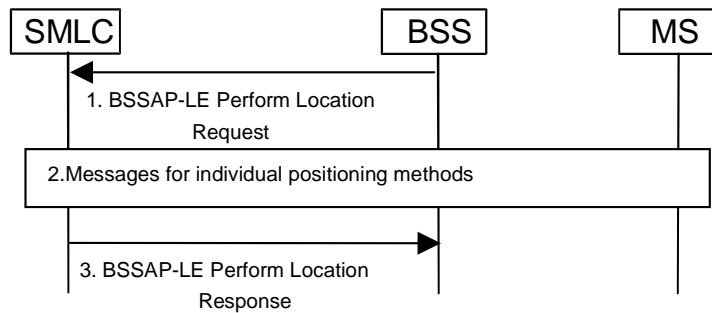


Figure 28a: Common Positioning Procedure for PS Domain

- 1) The BSS sends the BSSAP-LE Perform Location Request message to request the SMLC to start the positioning procedure. The Location Type, and Current Cell Identifier IEs are always included. If the Timing Advance value for the MS is available in the BSS, it shall be included (in BSSLAP APDU IE). Depending on the type of location request and the MS capability, additional parameters may be included to provide Measurement Report (in BSSLAP APDU IE), Packet Measurement Report, LCS Client Type, LCS Capability, LCS Priority, LCS Quality of Service, and A-GNSS Assistance Data. In addition, the IMSI and / or the IMEI of the mobile station involved in the positioning procedure may be provided by the BSS in order to allow the SMLC to maintain a context between subsequent requests for a mobile station, to tune positioning for each mobile station and to add more options for SMLC diagnostics.
- 2) See step 2 of clause 9.2 "Common Positioning Procedure for CS Domain in A/Gb mode". For a MS that only supports EC-GSM-IoT only the TA based positioning method is supported, see clause 9.3a.
- 3) The SMLC sends the BSSAP-LE Perform Location Response message to the BSS. A location estimate, velocity estimate, positioning data, deciphering keys, or LCS Cause may be included.

9.2b Common Positioning Procedure for Iu mode

This procedure is common to all positioning methods in the Iu mode.

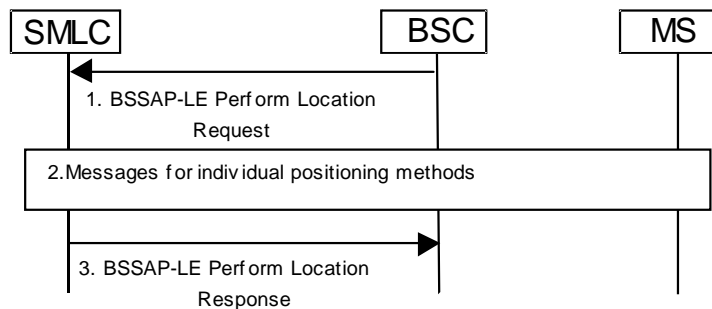


Figure 28b: Common Positioning Procedure

1. The BSC sends the BSSAP-LE Perform Location Request message to request the SMLC to start the positioning procedure.
2. See step 2 of Clause 9.2 "Common Positioning Procedure for CS Domain in A/Gb Mode."
3. The SMLC sends the BSSAP-LE Perform Location Response message to the BSC containing any location estimate (with optional velocity estimate) or deciphering keys. In case of failure the cause value may be included.

9.2c GPRS Cell Change for the PS Domain in A/Gb mode

9.2c.1 Intra-BSS Cell Change

The procedure shown below is used in order to keep an SMLC updated about Intra-BSS cell changes during a positioning procedure for a target MS in the PS domain in A/Gb-mode (note that unlike the CS domain and handover, the BSSLAP reset procedure is not used). The following procedure is applicable except when U-TDOA positioning is ongoing in the BSS as described in sub-clause 9.5.2.4 of this specification.

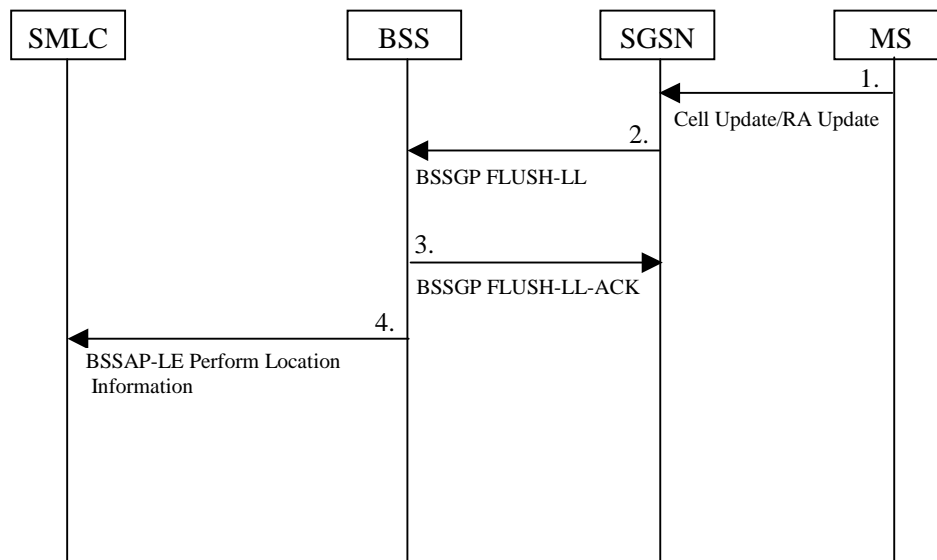


Figure 28c: Cell Change with BSSAP-LE Perform Location Information for the PS Domain

1. The MS detects a cell change and sends a cell update message or routing area update message to the SGSN (for more information, see 3GPP TS 23.060).
2. The SGSN sends a BSSGP FLUSH-LL PDU to the BSS. If the cell change is an Inter-NSE Cell Change, the NSEI of the new cell is provided.
3. The BSS acknowledges by sending a BSSGP FLUSH-LL-ACK PDU to the SGSN.
4. The BSS detects that a positioning procedure is active and the BSS is able to continue the positioning procedure in the new cell and sends a BSSAP-LE Perform Location Information message to the SMLC. This message contains the Cell Identifier for the new cell. If the Timing Advance value for the MS in the new cell is available in the BSS, it shall also be included. The BSS may send this message either if it receives the indication from the SGSN about the cell change (the BSSGP FLUSH-LL) or if it detects the cell change on its own (e.g. network controlled cell reselection).

9.2c.2 Inter-BSS Cell Change

The procedure shown below is used to abort the positioning procedure when an Inter-BSS cell change occurs for a target MS in the PS domain in A/Gb-mode. The following procedure is applicable except when U-TDOA positioning is ongoing in the BSS as described in sub-clause 9.5.2.5 of this specification.

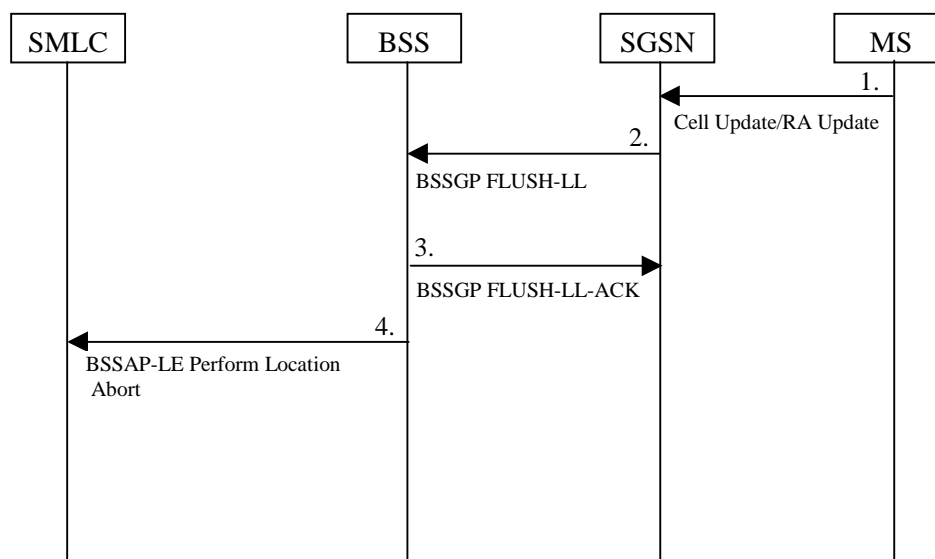


Figure 28d: Cell Change with positioning abort for the PS Domain

1. The MS detects a cell change and sends a cell update message or routing area update message to the SGSN (for more information, see 3GPP TS 23.060).
2. The SGSN sends a BSSGP FLUSH-LL PDU to the BSS. The NSEI of the new cell is provided.
3. The BSS acknowledges by sending a BSSGP FLUSH-LL-ACK PDU to the SGSN.
4. The BSS detects that a positioning procedure is active and that the BSS is not able to continue the positioning procedure in the new cell (e.g. Inter BSS Cell Change) and sends a BSSAP-LE Perform Location Abort message to the SMLC. The IE LCS Cause indicates the reason for the abort (e.g. “Inter BSS Cell Change”). The BSS then awaits the BSSAP-LE Perform Location Response from the SMLC, which it will forward in a BSSGP Perform Location Response to the SGSN.

9.3 TA Based Positioning in CS Domain for A/Gb-mode

The TA is based on the existing Timing Advance (TA) parameter. The TA value is known for the serving BTS. To obtain TA values in case the MS is in idle mode a special call, not noticed by the GSM subscriber (no ringing tone), is set up. The cell-ID of the serving cell and the TA is returned as the result of the TA.

9.3.1 Definition of TA states

9.3.1.1 MS in IDLE State

In IDLE state the MS may be paged or may request an originating (e.g. emergency) call. The paging response message or CM Service Request, in each case respectively, received in COMPLETE_LAYER_3 message may contain location information that includes the TA value. If available, the TA value and other location information shall be provided to the SMLC by the requesting BSC along with the current serving cell ID in the BSSAP-LE Perform Location request. This enables TA based positioning in the SMLC without any further interactions.

9.3.1.2 MS in DEDICATED State

In DEDICATED state the SMLC shall send a TA_REQUEST to request the TA value from the serving BSC. The BSC shall respond with either a TA_RESPONSE carrying the TA value and possibly other radio measurements from the MS or a Reset. The associated procedure is described in the next clause.

9.3.2 TA Positioning Procedure

This TA positioning procedure is generic for a standalone SMLC or integrate SMLC in the BSC.

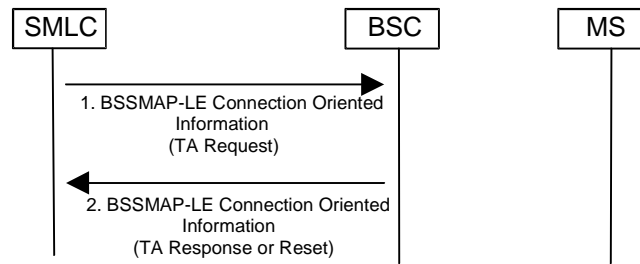


Figure 29: TA Positioning Procedure for the SMLC in the CS Domain

- 1) The SMLC sends a BSSAP-LE Connection Oriented Information message to the BSC serving a particular target MS. The APDU parameter in this message contains a BSSLAP TA Request.
- 2) Provided the location area for the target MS has not changed or, if changed, was previously reported to the SMLC, the BSC returns the current TA value and current serving cell for the target MS to the SMLC in a BSSLAP TA response contained within a BSSAP-LE Connection Oriented Information message. The TA response may also include the latest measurement results received from the target MS for the serving and neighbouring cells. If the location area for the target MS has changed since the location request was first sent to the SMLC and if the new location area has not yet been reported to the SMLC, the BSC shall return a BSSLAP Reset to the SMLC within a BSSMAP-LE Connection Oriented Information message. The Reset shall include the current serving cell, the current location area code, a cause value indicating “intra-BSC handover” and the current TA value and may include the latest measurement results received from the target MS for the serving and neighboring cells. The SMLC then derives a location estimate for the target MS based on the received serving cell ID, location area code if included, TA value and other measurement results if included.

NOTE: In the case of a previous intra-BSC handover to a cell in a different PLMN (different MCC, MNC combination), the SMLC would receive a BSSLAP Reset containing the new location area code and new cell ID. The SMLC may then deduce the new MCC and MNC from the uniqueness, when this applies, of the combined values for the new location area code and cell ID compared to the corresponding values for neighbouring cells.

9.3.3 Unsuccessful TA positioning procedure in BSC

There are three messages defined to handle error scenarios during positioning procedure in BSC. The messages are 1) Reject, 2) Abort and 3) Reset. Refer to 3GPP TS 48.071 [21] for details.

After receiving the BSSLAP TA Request in BSC, a Reject will be sent with proper cause value from BSC to SMLC in "BSSAP-LE Connection Oriented Information Message" if TA positioning cannot be performed in BSC at that time for reasons other than handover or another ongoing RR management procedure.

An Abort or Reset is possible if the TA positioning cannot be done in BSC during that time. Reset is sent to SMLC to indicate when the positioning needs to be restarted after temporary interruption due to intra BSC HO or other intra-BSC RR management. The contents of a Reset shall be as defined in step 2 in section 9.3.2. Abort is used to indicate to SMLC the failure of the current TA positioning attempt (e.g. due to inter-BSC handover) and allowing a new one from application level.

9.3a TA Based Positioning in PS Domain for A/Gb-mode

The TA is based on the existing Timing Advance (TA) parameter. The TA value is known for the serving BTS. To obtain TA values in case the MS is in packet idle mode and the value is not available in the BTS signalling is used to retrieve it. The cell-ID of the serving cell and the TA is returned as the result of the TA procedure.

If available, the TA value shall be provided to the SMLC by the requesting BSS in the BSSAP-LE Perform Location request. This enables TA based positioning in the SMLC without any further interactions. The current serving cell ID shall always be provided by the BSS to the SMLC.

9.3a.1 Definition of PS Domain TA Modes

9.3a.1.1 MS in Packet Idle Mode

When the BSS receives a TA Request message and the MS is in Packet Idle Mode and the TA value is not available in the BSS, the MS may be paged or may be sent a Packet Polling Request message. If there is a PBCCH allocated in the current cell, the BSS will send a Packet Polling Request message to the MS. If there is no PBCCH allocated in the current cell, the BSS will perform packet paging (sends a Paging Request Type 1, 2, or 3 message) for the MS.

The paging response message or Packet Control Acknowledgement message will provide the TA value to the BSS and this will be provided to the SMLC, possibly together with other radio measurements from the MS, in the TA Response message. The associated procedure is described below.

For an MS in EC operation the BSS will send an EC Paging Request message to the MS.

9.3a.1.2 MS in Packet Transfer Mode

When the BSS receives a TA Request message and the MS is in Packet Transfer Mode and the TA value is not available in the BSS the MS shall be sent a Packet Polling Request message.

The Packet Control Acknowledgement message will provide the TA value to the BSS and it will be provided to the SMLC, possibly together with other radio measurements from the MS, in the TA Response message. The associated procedure is described in the next clause.

For an MS in EC operation the BSS shall send an EC Packet Polling Request message instead of a Packet Polling Request message to the MS. The EC Packet Control Acknowledgement message will provide the TA value to the BSS.

9.3a.2 TA Positioning Procedure

This TA positioning procedure is generic for a standalone SMLC or integrate SMLC in the BSS.

For a TA positioning procedure when the MS is in EC operation see sub-clause 9.3a.2a.

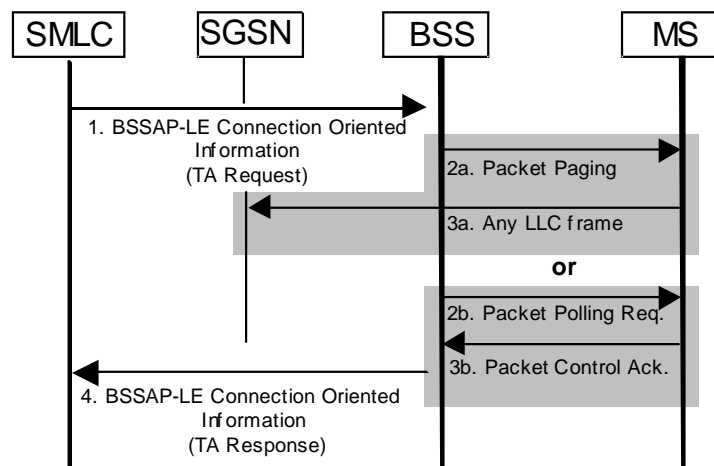


Figure 29a: TA Positioning Procedure for the SMLC in the PS Domain

- 1) If the SMLC has not already received the TA Value in the BSSAP-LE Perform Location Request message, the SMLC sends a BSSAP-LE Connection Oriented Information message to the BSS serving a particular target MS. The APDU parameter in this message contains a BSSLAP TA Request.
- 2) If the TA value is available in the BSS, the BSS immediately returns it in step 4, otherwise the BSS either performs a packet paging procedure or sends a Packet Polling Request message (for details, see clause 9.5.2).
 - 2a) If there is no PBCCH allocated in the current cell and the MS is in Packet Idle Mode, the BSS will perform packet paging (sends a Paging Request Type 1, 2, or 3 message) for the MS.

- 2b) If there is a PBCCH allocated in the current cell or the MS is in Packet Transfer Mode, the BSS will send a Packet Polling Request message to the MS.
- 3) The MS responds to the BSS.
 - 3a) If the MS receives the packet paging it will send a page response.
 - 3b) If the MS receives a Packet Polling Request message it will return a Packet Control Acknowledgement message.
- 4) The BSS returns the current TA value and current serving cell for the target MS to the SMLC in a BSSLAP TA response contained within a BSSAP-LE Connection Oriented Information message. The TA response may also include the latest measurement results received from the target MS for the serving and neighbouring cells. The SMLC then derives a location estimate for the target MS based on the received serving cell ID, TA value and other measurement results if included.

9.3a.2a TA Positioning Procedure for an MS in EC operation

This TA positioning procedure is generic for a standalone SMLC or an integrated SMLC in the BSS.

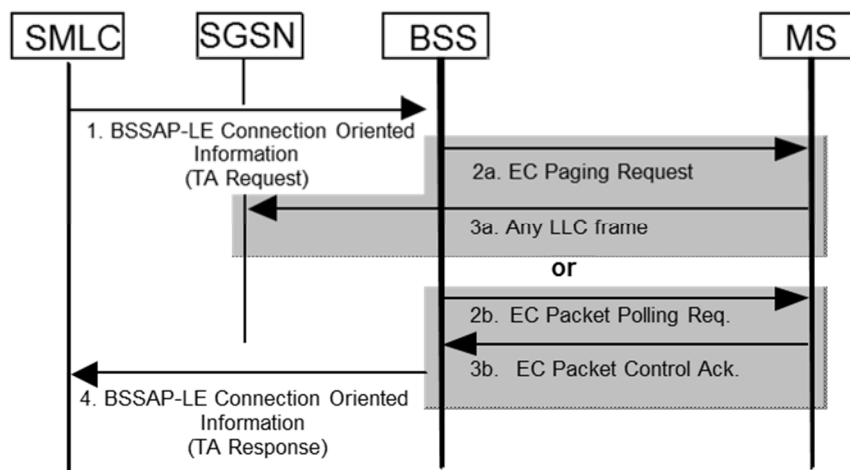


Figure 29b: TA Positioning Procedure for the SMLC when the MS is in EC operation

- 1) If the SMLC has not already received the TA Value in the BSSAP-LE Perform Location Request message, the SMLC sends a BSSAP-LE Connection Oriented Information message to the BSS serving a particular target MS. The APDU parameter in this message contains a BSSLAP TA Request.
- 2) If the TA value is available in the BSS, the BSS immediately returns it in step 4, otherwise the BSS either performs a paging procedure or sends an EC Packet Polling Request message to the MS.
 - 2a) If the MS is in Packet Idle Mode, the BSS will send an EC-Paging Request message to the MS.
 - 2b) If the MS is in Packet Transfer Mode, the BSS will send an EC Packet Polling Request message to the MS.
- 3) The MS responds to the BSS.
 - 3a) If the MS receives the paging it will send a page response.
 - 3b) If the MS receives an EC Packet Polling Request message it will return an EC Packet Control Acknowledgement message.
- 4) The BSS returns the current TA value and current serving cell for the target MS to the SMLC in a BSSLAP TA response contained within a BSSAP-LE Connection Oriented Information message. The SMLC then derives a location estimate for the target MS based on the received serving cell ID and the TA value.

9.3a.3 Unsuccessful TA positioning procedure in BSS

There are three messages defined to handle error scenarios during positioning procedure in BSS. The messages are 1) Reject, 2) Abort and 3) Reset. Refer to 3GPP TS 48.071 [21] for details. The Reset message does not apply for PS domain.

After receiving the BSSLAP TA Request in BSS, a Reject will be sent with proper cause value from BSS to SMLC in "BSSAP-LE Connection Oriented Information Message" if TA positioning cannot be performed in BSS at that time for reasons other than handover or another ongoing RR management procedure.

An Abort is possible if the TA positioning cannot be done in the BSS during that time. Abort is used to indicate to SMLC the failure of the current TA positioning attempt (e.g. due to reception of an BSSGP_Perform_Location_Abort from the SGSN) and allowing a new one from application level.

9.4 E-OTD and A-GNSS Positioning Procedures

9.4.1 General procedures

For any location request where the highest priority level is assigned and MS-based A-GNSS positioning is not used, the SMLC functionality shall provide sufficient assistance data to a target MS to enable a location estimate, velocity estimate, or location measurements to succeed according to the required QoS on the first attempt. The SMLC shall not assume in this case that the target MS already possesses assistance data. For a lower priority location request or when MS-based A-GNSS positioning is used, the SMLC may reduce the assistance data provided to a target MS on the first location attempt.

In the high priority case with MS-assisted GNSS for the first positioning attempt, acquisition assistance data shall be included in the RRLP measure position request message.

9.4.2 Positioning Request

This signaling flow is generic for all MS based or assisted location methods (MS Based E-OTD, MS Assisted E-OTD, MS Based A-GNSS, and MS Assisted A-GNSS). The signaling flow below applies to integrated and standalone SMLCs in a circuit switched network.

If the SMLC desires to avoid lower layer (e.g. BSSAP-LE) segmentation, see clause 6.1.2, and transfer the LCS assistance data more reliably, this procedure may be preceded by an "Assistance Data Delivery" procedure. Note, that part of the entire set of assistance data may be included in the RRLP Measure Position Request even when the message is preceded by an "Assistance Data Delivery" procedure.

If the MS has indicated support for providing MS positioning capabilities using RRLP in the MS Classmark 3 IE for GSM (see 3GPP TS 24.008), in the PS LCS Capability IE for GERAN Gb mode (see 3GPP TS 24.008), or in the MS Positioning Capability IE for GERAN Iu mode, this procedure may be preceded by a "Positioning Capability Transfer" procedure.

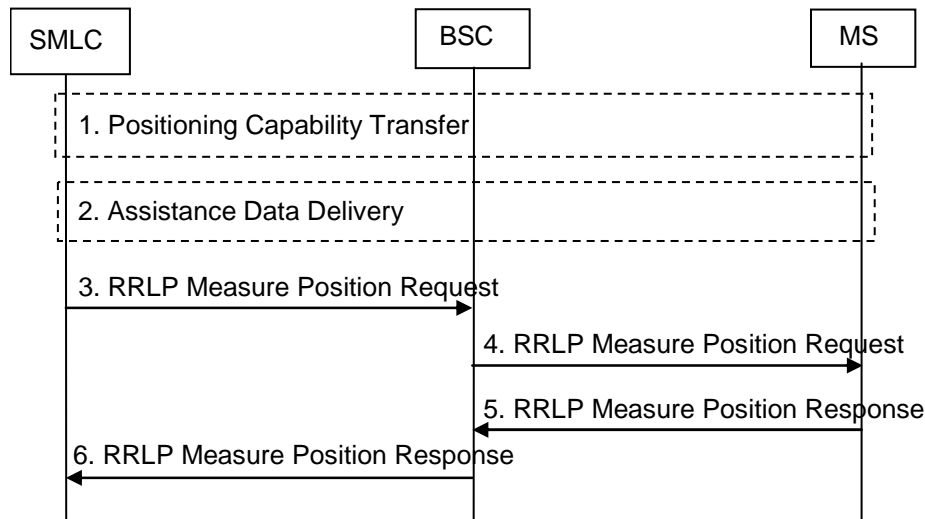


Figure 30: E-OTD or A-GNSS Position Request Flow

- 1) The SMLC may precede the RRLP MEASURE POSITION REQUEST or Assistance Data Delivery procedure with a Position Capability Transfer procedure, if the MS supports the transfer of MS positioning capabilities using RRLP.
- 2) The SMLC may precede the RRLP MEASURE POSITION REQUEST with an optional Assistance Data Delivery procedure.
- 3) The SMLC determines possible assistance data and sends RRLP MEASURE POSITION REQUEST to the BSC.
- 4) The BSC forwards the positioning request including the QoS and any assistance data to the MS in a RRLP MEASURE POSITION REQUEST.
- 5) The MS performs the requested E-OTD or GNSS measurements, if needed assistance data is available in the MS. If the MS is able to calculate its own location and this is required and needed assistance data is available in MS, the MS computes a location estimate based on E-OTD or GNSS measurements. In case of E-OTD, any data necessary to perform these operations will either be provided in the RRLP MEASURE POSITION REQUEST or available from broadcast sources. In case of A-GNSS (both MS based and MS assisted) and first positioning attempt, a minimum set of A-GNSS assistance data will be either provided in the RRLP MEASURE POSITION REQUEST or available from broadcast sources. For further positioning attempt (failure in first attempt due to missing assistance data), sufficient A-GNSS assistance data, possibly excluding the assistance data sent in the first attempt, will be provided in the RRLP MEASURE POSITION REQUEST and possibly preceding RRLP ASSISTANCE DATA messages. The resulting E-OTD or GNSS measurements or E-OTD or GNSS location estimate (with optional velocity estimate) are returned to the BSC in a RRLP MEASURE POSITION RESPONSE. If the MS was unable to perform the necessary measurements, or compute a location, a failure indication identifying the reason for failure (e.g. missing assistance data) is returned instead. In case of A-GNSS, if the MS was unable to compute a location, the GNSS measurements are also optionally returned if allowed by the network. If the RRLP message is larger than the RRLP maximum PDU size, several RRLP MEASURE POSITION RESPONSE messages are sent (i.e. the RRLP pseudo-segmentation is used).
- 6) BSC forwards the RRLP MEASURE POSITION response to SMLC.

9.4.3 Assistance Data Delivery

This signalling flow is generic for MS Based and MS Assisted E-OTD, and MS Based or MS Assisted A-GNSS in a circuit switched network.

If the SMLC desires to avoid lower layer (e.g. BSSAP-LE) segmentation and transfer the LCS assistance data more reliably, the sequence 1-4 illustrated in the figure below may be repeated several times to deliver more assistance data than can be sent by one RRLP Assistance Data Delivery message. In this case, each individual message is independent such that the data received in one message is stored in the MS independently of the other RRLP Assistance Data messages (i.e. an error of delivery of one message does not require a retransmission of all the RRLP Assistance Data messages). The SMLC shall indicate in the RRLP ASSISTANCE DATA message if more RRLP ASSISTANCE DATA

messages will be used after the current one in order to deliver the entire set of assistance data. Data that is specific to the current cell should be sent in the last message this is recommended so that assistance data for the correct cell is available to the MS after a handover.

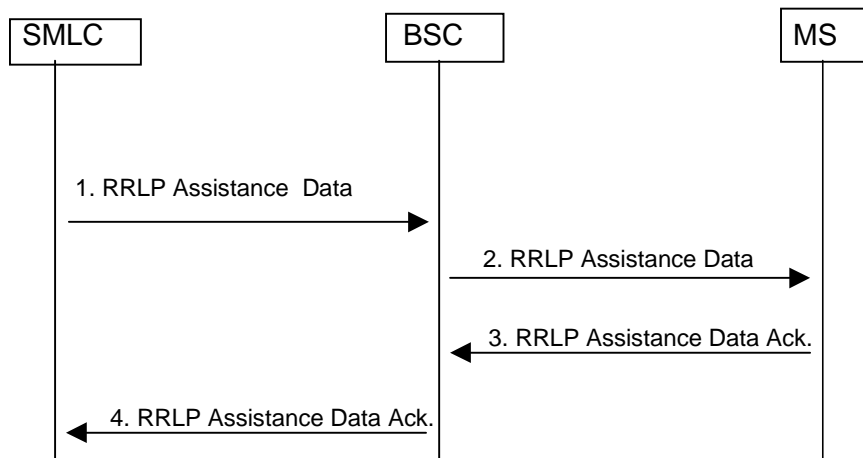


Figure 31: E-OTD or A-GNSS Assistance Data Delivery Flow

- 1) The SMLC determines assistance data and sends it in the RRLP ASSISTANCE DATA message to the BSC.
- 2) The BSC forwards the assistance data to the MS in a RRLP ASSISTANCE DATA message.
- 3) The MS acknowledges the reception of complete assistance data to the BSC with a RRLP ASSISTANCE DATA Ack.
- 4) The BSC forwards the RRLP ASSISTANCE DATA Ack message to the SMLC.

9.4.3a Positioning Capability Transfer

The purpose of this procedure is to enable the SMLC to obtain the positioning capabilities of the MS, the types of assistance supported and the types of assistance data that may be needed from the SMLC. MS support for this procedure can be indicated to the SMLC using the MS Classmark 3 IE for GSM (see 3GPP TS 24.008), the PS LCS Capability IE for GERAN Gb mode (see 3GPP TS 24.008) and the MS Positioning Capability IE for GERAN Iu mode.

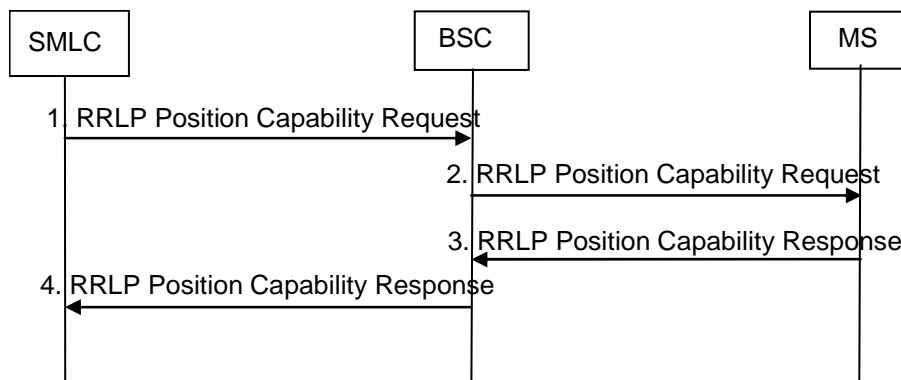


Figure 31a: RRLP Position Capability Transfer Flow

- 1) The SMLC determines that the target MS supports MS Positioning Capability Transfer using RRLP and sends a Positioning Capability Request message to the BSC.
- 2) The BSC forwards the Positioning Capability Request message to the MS.

- 3) The MS sends the Positioning Capability Response message to the BSC. The response message shall include the positioning capabilities of the MS and the types of supported assistance data (if applicable). The message may include the types of assistance needed by the MS to obtain a location estimate or positioning measurements.
- 4) The BSC forwards the Positioning Capability Response message to the SMLC.

9.4.4 Error Handling for E-OTD and A-GNSS in CS Domain

This clause describes error handling for positioning and transfer of assistance data for E-OTD and A-GNSS. For a description of error handling involving segmentation, and more details on usage of a BSSLAP Abort, Reject and Reset refer to clause 8.5 Exception Procedures.

- Case 1: When the RRLP request comes to BSC for E-OTD and A-GNSS, The BSC will send a BSSLAP reject message to SMLC if the request cannot be supported in the BSC for reasons other than an ongoing intra BSC or inter BSC handover or other ongoing RR management procedure. For an ongoing intra BSC HO or other RR management procedure, the BSC shall return a BSSLAP Reset when the handover or RR management procedure is complete. The SMLC may then start the RRLP request (if there is time) again. For ongoing inter-BSC HO, the BSC shall return a BSSLAP Abort. The location service request may then restart from the LCS Client, VMSC or SGSN.
- Case 2: When the RRLP request comes to BSC from SMLC, BSC sends the "RRLP request" to the MS if there is no ongoing HO or other RR management procedure at that point. If an intra-BSC HO or other RR management procedure is initiated in BSC, the BSC sends the HO or other RR management command to MS. A timer will then be started in BSC, the duration of which is network dependent, but typically 6 (six) seconds. Upon receiving the HO or other RR management command, the MS will stop the location procedure and start on handover or other RR management procedure, since this has higher priority than location. The MS will then send the HO complete or other RR management response message to BSC. When this message is received before the expiration of BSC timer, a BSSLAP Reset message will be sent to SMLC from BSC. The Reset will tell SMLC to start another location service request if there is enough time.
- Case 3: During intra-BSC HO or other intra-BSC RR management procedure, if a HO complete or RR management procedure completion was not received in BSC and the corresponding timer expired. In this case a reset or abort message will be sent to SMLC indicating MS timeout. The location service may then restart from either the SMLC if a reset was sent or from the LCS Client, VMSC or SGSN if an abort was sent.
- Case 4: If an inter-BSC handover is needed during a location procedure or if the BSC times out on an RRLP response from the target MS, the BSC shall send a BSSLAP Abort to the SMLC. The location service attempt may then be restarted from the LCS Client, VMSC, or SGSN.

9.4.5 Error Handling for the SMLC in CS Domain

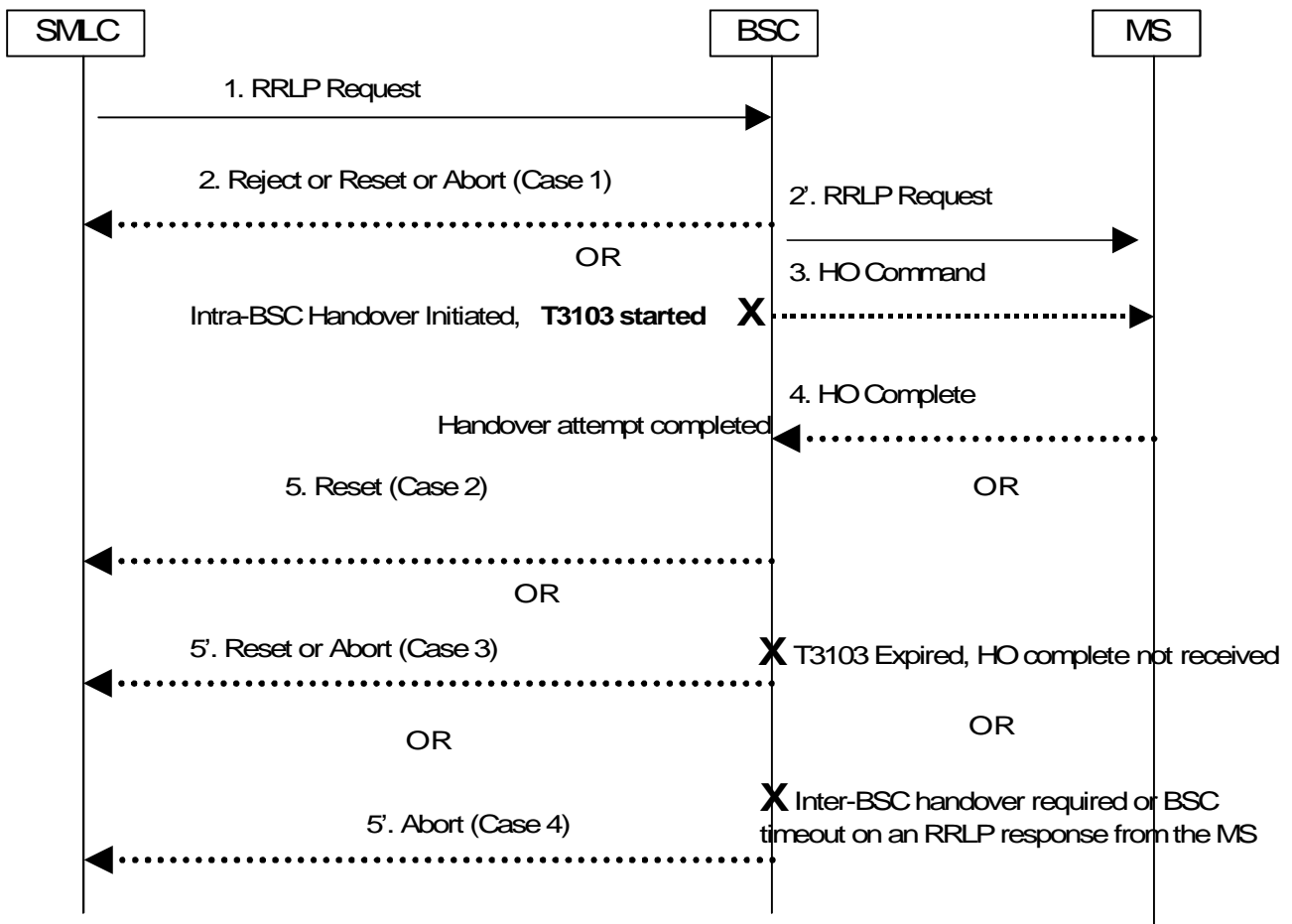


Figure 32: Error Handling for the SMLC in the CS Domain

9.4.5a Error Handling for E-OTD and A-GNSS in PS Domain

- Case 1: When the RRLP request comes to BSS for E-OTD and A-GNSS, the BSS will send a BSSLAP reject message to SMLC if the request cannot be supported in the BSS.
- Case 2: When the RRLP request comes to BSS from SMLC, BSS sends the "RRLP request" to the MS via the SGSN and starts position supervision timer. After this, if the BSS determines that the current location procedure cannot be continued, the BSS sends an abort message to the SMLC. Notice that an MS reselection to a new cell is not a reason for the BSS to abort the procedure.
- Case 3: If the position supervision timer times out in BSS before the RRLP response from the target MS is received, the BSS shall send a BSSLAP Abort to the SMLC. The location service attempt may then be restarted from the LCS Client, VMSC, or SGSN.

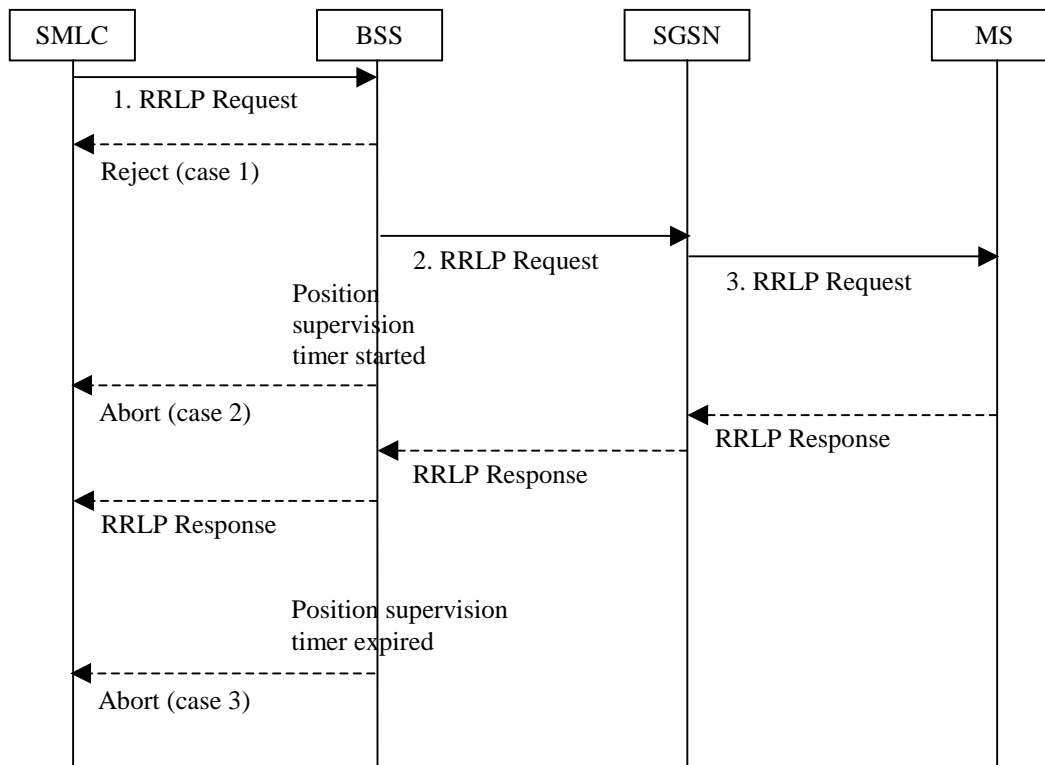


Figure 32a: Error Handling for the SMLC in PS domain

9.4.6 Broadcast of Assistance Data

In MS Based E-OTD, MS Based GPS and MS Assisted A-GNSS systems, there may be a need for assistance data to be broadcast to the MS. The assistance data to be broadcast for MS Based E-OTD contains the Real Time Difference (RTD) values (in case of a non-synchronised network) and Base Transceiver Station (BTS) coordinates. In addition, the broadcast data contains other information simplifying the E-OTD measurements. The broadcast of A-GNSS assistance data may make available the same information as in A-GNSS point-to-point signalling. It improves the location accuracy for MS Based implementations, increases the sensitivity, enables LMU-independent time dissemination and assists the acquisition of satellite signals for both MS Based and MS Assisted implementations.

The CS mechanism (Cell Broadcast on CBCH) is used for broadcast of assistance data for all MSs, irrespective of which domain (CS or PS) they are located in. Notice that it may take longer for an MS in the PS domain compared to the CS domain to read all the broadcast data. This is because the PBCCH is not co-ordinated with the CBCH and therefore, the MS may have to skip reading a CBCH slot in order to listen for a potential paging message.

The E-OTD assistance data to be broadcast is in compressed format where the redundant information is not included. The MS is capable to reconstruct the E-OTD assistance data using the message header information. The length of the message is depending on how many neighbours are included in the E-OTD assistance data as well as whether the redundant information can be removed from the message. The typical size of one broadcast message will be less than 82 octets. Part of the broadcast message (serving and neighbour base station coordinates) may be ciphered.

The contents of the broadcast message for the E-OTD and A-GNSS assistance data is described in 3GPP TS 44.035 [16]. The support for these broadcast messages is optional for network and MS.

The broadcast channel which is used to broadcast the E-OTD and A-GNSS assistance data make use of the existing basic or extended CBCH and SMSCB DRX service. The LCS broadcast messages need to be either scheduled, or prioritised over other broadcast messages to avoid any delay.

9.4.6.1 Point-To-Multipoint Assistance Data Broadcast Flow

This signalling flow is generic for MS Based E-OTD, MS Based A-GNSS and MS Assisted A-GNSS methods. The E-OTD/A-GNSS Assistance Data Broadcast Message is created in SMLC and the whole message including the ciphered parts and parameters to control the transfer are transferred with below flow from SMLC to MS. SMSCB DRX service is used for LCS assistance data broadcast. Prior receiving the first schedule message MS should read first block of each

message lot to be able to receive the LCS Broadcast Data or the schedule message. After receiving the schedule message MS should receive the LCS Broadcast Data messages according the schedule information.

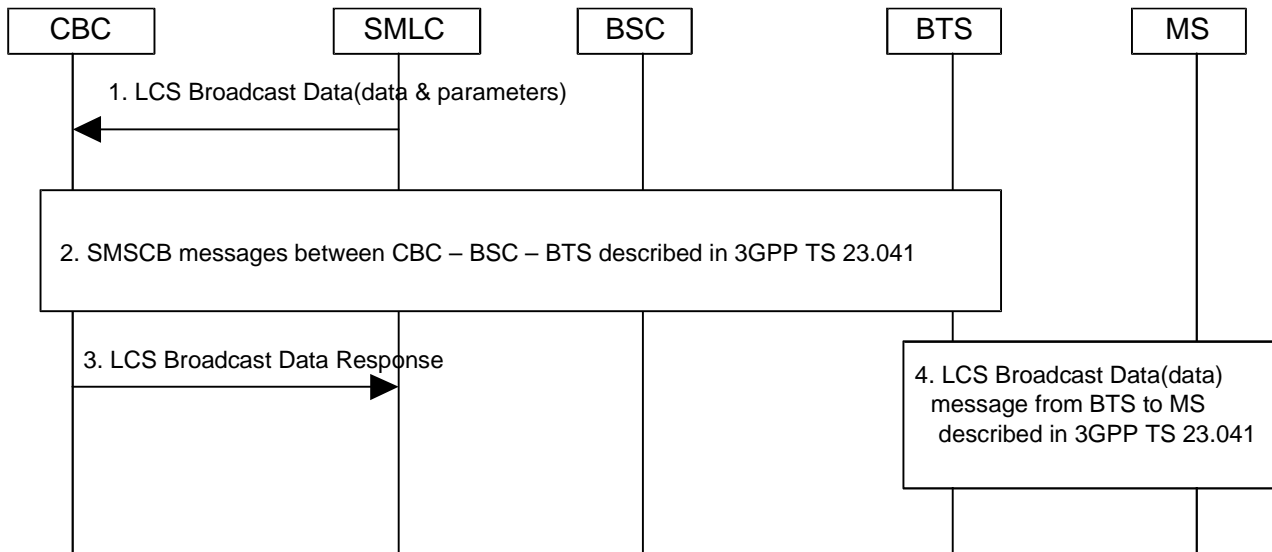


Figure 33: E-OTD/A-GNSS Broadcast Data Flow

- 1) SMLC sends the complete broadcast message to CBC with LCS Broadcast Data message. This LCS Broadcast Data message contains the data to be broadcasted as well as parameters that indicate to which BTS the broadcast message is targeted and what time the broadcast should happen. LCS Broadcast Data (data & parameters) message may also contain the SMSCB scheduling information which can be utilised for the SMSCB DRX feature specified in 3GPP TS 44.012 [13] specification. SMSCB DRX operation is required in order that MS performance can be optimised.
- 2) CBC starts message transfer to BSC and BTS according to 3GPP TS 23.041 [6].
- 3) LCS Broadcast Data Response message from CBC to SMLC is used to indicate that the LCS Broadcast Data has been delivery request has been fulfilled. This message is not mandatory
- 4) BTS starts the message transfer to MS according to 3GPP TS 23.041 [6].

Implementations that have SMLC and/or CBC integrated into BSC may use other message signalling.

9.4.6.2 Ciphering

In order for the operators to control the access to the assistance data, parts of the broadcast data may be ciphered. Ciphering is done with a specific key delivered by the network for this purpose. The deciphering keys may be requested by the MS as described in 3GPP TS 23.271 [7]. The LCS Broadcast Data, when ciphered, will be partially ciphered according to the LCS broadcast message definitions specified in 3GPP TS 44.035 [16]. The parts that will be ciphered in E-OTD LCS Broadcast Data message are neighbour RTD values, serving and neighbour BTS coordinates. For A-GNSS, all assistance data may be ciphered, The MS is capable to decipher the broadcast message (ciphered parts) using the cipher key (56 bits) delivered from the Core Network to MS and using the Ciphering Serial Number (16 bits) included in the broadcast message.

9.4.6.2.1 Algorithm

The algorithm used for ciphering is the standard 56-bit DES algorithm. The deciphering of broadcast messages is done in the MS. SMLC ciphers the LCS Broadcast Data message (part of message is ciphered) using the deciphering keys (56 bits) and Ciphering Serial Number (16 bits) included in broadcast message using 56-bit DES algorithm.

The ciphered part is variable length with one bit resolution. From LCS Broadcast Data message header MS can compute what part of message is ciphered.

Inputs to the 56-bit DES algorithm are the following:

- 56-bit key K (deciphering key);
- 16-bit Ciphering Serial Number from broadcast message which is denoted here by IV (initialisation vector);
- plaintext bits (the ciphered part of broadcast message).

Encryption is done by producing a mask bit stream which is then added bit-by-bit to the plaintext data (XOR-operation) to obtain the cipher text data. First IV is concatenated with 0-bits in order to achieve a 64-bit block I_1 . This block is then encrypted by the DES algorithm using the key K. Output is a 64-bit block I_2 . This constitutes the first 64 bits of the mask bit stream. If the message is longer than 64 bits, then more bits are needed. Those are produced by encrypting I_2 again by the DES algorithm using the key K. Output is a 64-bit block I_3 . This constitutes the next 64 bits of the mask bit stream. This iteration is continued until enough bits are produced. The unnecessary bits from the last 64-bit block I_j are discarded. Below figure describes the first two mask bit generations and the two ciphered 64-bit blocks.

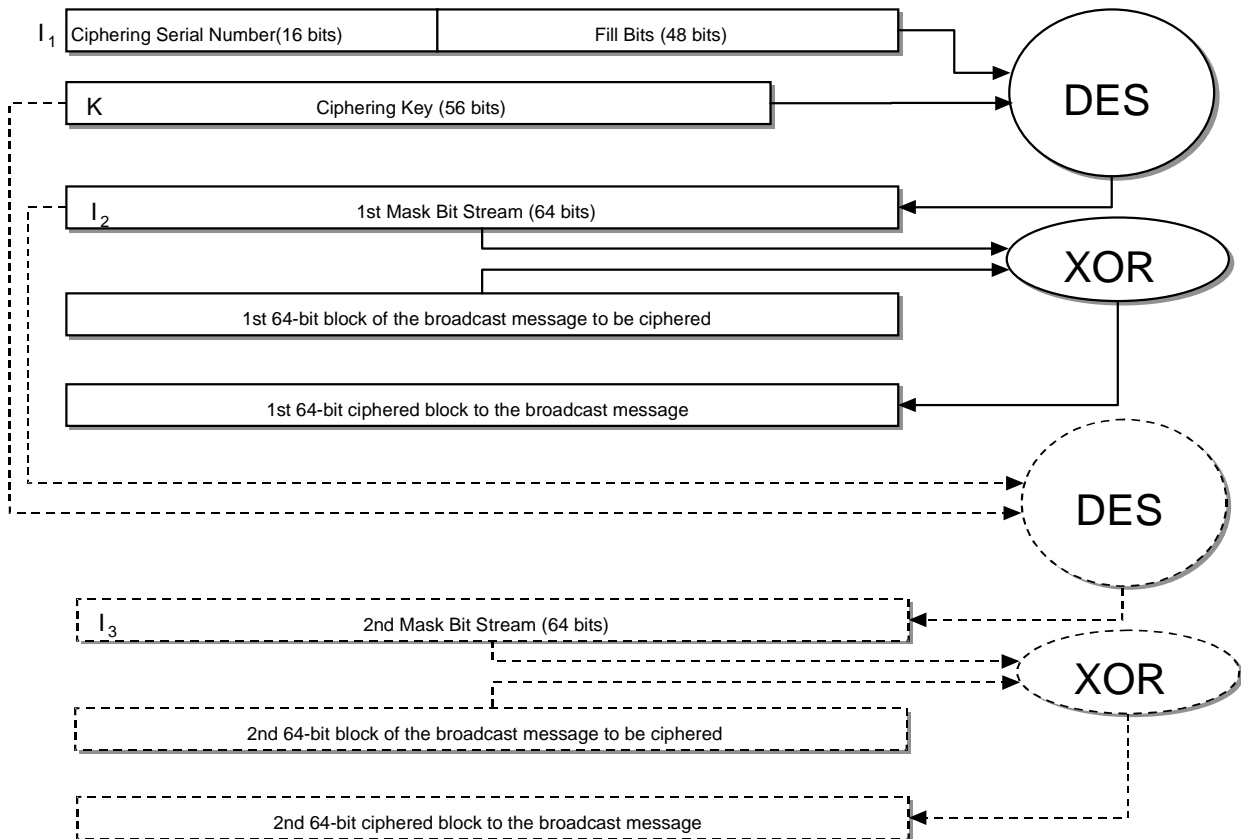


Figure 34 : Ciphering Algorithm

Decryption is done similarly. The same mask bit stream is produced. This time the mask stream bits are added bit-by-bit (XORed) to the ciphertext data bits. The result will be the plain text data.

9.4.6.3 Deciphering key control and delivery to MS

The deciphering keys are needed in MS if the LCS Broadcast Data (ciphered parts) is ciphered. The deciphering keys' control system contains two keys (the Current Deciphering Key and the Next Deciphering Key) and the Ciphering Key Flag (indicating the current Ciphering Key Flag state in the location area in the time that the deciphering key set is delivered from SMLC to MS). Two Deciphering Keys are needed in order to overcome the problem of unsynchronised nature of the periodic location updates that MSs make in the location area. The SMLC controls the keys and there are following requirements related to the deciphering keys:

- Deciphering Key Set (Current and Next Deciphering Key, Ciphering Key Flag) are always location area specific.
- One SMLC controls the deciphering key set changes inside the location area and in case several SMLCs in the location area then one coordinating SMLC for the deciphering key set control must be nominated. The SMLC configuration is done with O&M procedures.

- The coordinating SMLC delivers the new deciphering key set to the other SMLCs with SMLCPP protocol when the deciphering key set changes. The Ciphering Key Flag in the LCS Broadcast Data message is changed only when the coordinating SMLC changes the deciphering key set and delivers the new set to other SMLCs in the same location area.
- The SMLCs upon receiving the new deciphering key set, start using immediately the new set in the LCS Broadcast Data message. The coordinating SMLC also starts using the new set same time.

The deciphering key set changes always following way when the new set is generated:

- The Next Deciphering Key comes to the Current Deciphering Key in the new set.
- One new key is taken into use and named as the Next Deciphering Key.
- The Ciphering Key Flag changes the state.

The Ciphering Key Flag controls the MS key usage (Current/Next Deciphering Key) as follows:

- After receiving the new deciphering key set, MS starts using the new set immediately.
- The Ciphering Key Flag in the LCS Broadcast Data message and the one received returned to the MS should have same polarity. This means that MS starts using the Current Deciphering Key immediately.
- When the Ciphering Key Flag state changes in the LCS Broadcast Data message then MS starts to use the Next Deciphering Key for deciphering the broadcast message. The Next Deciphering Key becomes now the Current Deciphering Key in MS.

Figure 35 describes the deciphering key delivery mechanism.

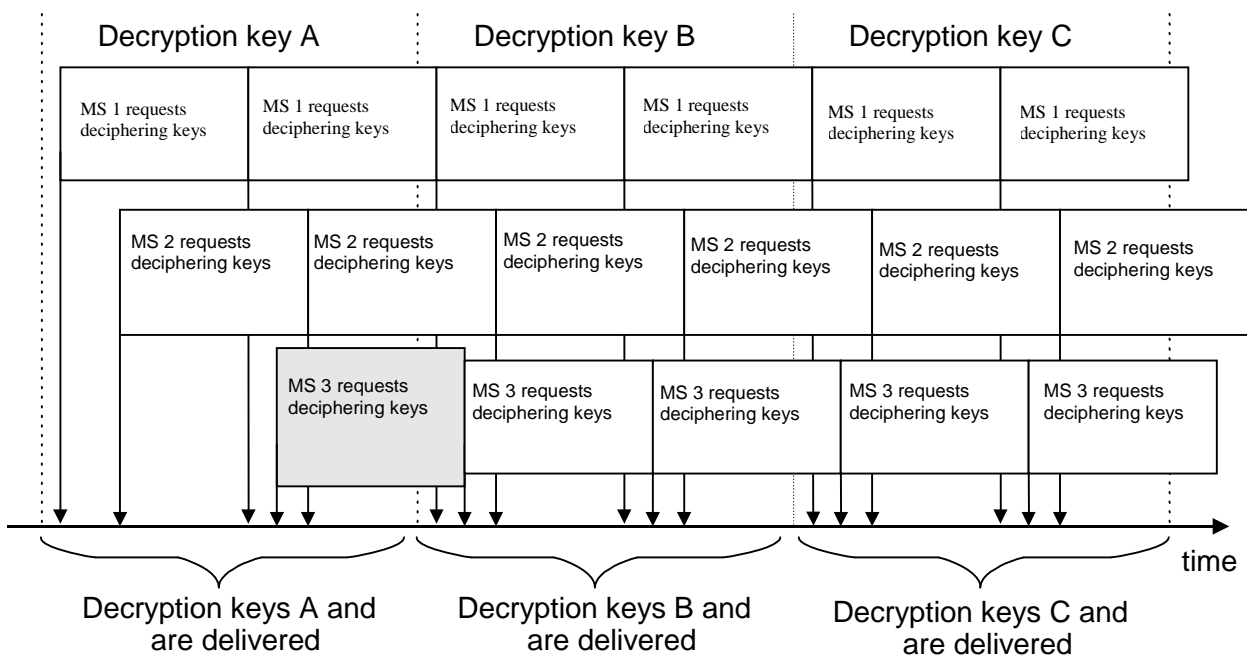


Figure 35: Deciphering key delivery

- First the key A is the Current Deciphering Key and key B is the Next Deciphering Key.
- When the SMLC changes to use the key B (Next Deciphering Key) then the Deciphering Key Flag state is changed in the LCS Broadcast Data message. At this point the coordinating SMLC delivers the new deciphering key set to other SMLCs in the same location area as well as to MS when MS is requesting the keys during the location update (IMSI Attach, Normal or Periodic Location Update).
- The new deciphering key set contains now key B as the Current Deciphering Key, key C as new Next Deciphering Key and the Ciphering Key Flag currently in use in that location area.

- When the SMLC changes to use the key C (Next Deciphering Key) then the Ciphering Key Flag state is changed in the LCS Broadcast Data message. At this point the coordinating SMLC delivers the new deciphering key set to other SMLCs in same location area as well as to MS when MS is requesting the new set during the location update (IMSI Attach, Normal or Periodic Location Update).
- The new deciphering key set contains now key C as the Current Deciphering Key, key D as new Next Deciphering Key and the Ciphering Key Flag currently in use in that location area.

The process continues as above when the keys are changed. The lifetime of one key (Current/Next Ciphering Key) is minimum one periodic location update period used in the location area.

9.5 U-TDOA Positioning Procedures

9.5.0 General

Following the receipt of a location request message from the BSC, the U-TDOA capable SMLC interrogates the BSS for the RF channel information associated with the MS to be located. The SMLC uses this information to task the LMUs at the serving and surrounding cells. The LMUs are tasked to measure the identified RF channel(s) and thus provide a time reference from different LMUs. The time-of-arrival information from the tasked LMUs is returned to the SMLC where the MS location is calculated.

9.5.1 U-TDOA Positioning in CS Domain for A/Gb-mode

9.5.1.1 General Procedures

The U-TDOA location method uses the uplink energy transmitted by an MS to make a location determination. If the MS was in the dedicated mode, carrying subscriber traffic prior to the beginning of the location process, the energy associated with this subscriber traffic can be used to locate the MS. If the MS was placed in the dedicated mode by the MSC specifically for location determination purposes, either the SDCCH or TCH can be used for U-TDOA location purposes.

9.5.1.2 CS U-TDOA Messages and Procedures on the Lb Interface

The following section describes the positioning procedure for CS U-TDOA location determination on the Lb interface.

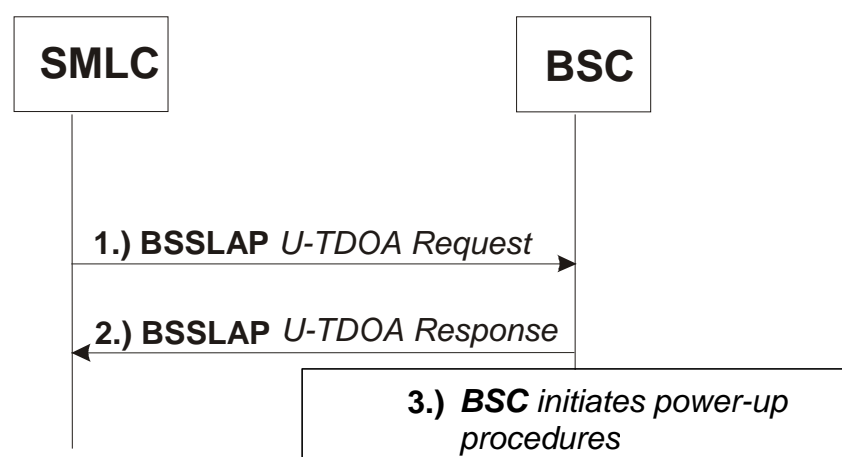


Figure 36: CS U-TDOA Positioning Procedure

1. The SMLC sends a BSSMAP-LE Connection Oriented Information message to the BSC that contains the embedded BSSLAP U-TDOA Request message. The U-TDOA Request message may contain the delta timer

value. The BSC starts the delta timer, received or internal, immediately after sending the U-TDOA Response message to the SMLC. The purpose of this timer is to define the maximum time during which the BSC supervises the location request.

2. The BSC sends a BSSMAP-LE Connection Oriented Information message to the SMLC that contains the embedded BSSLAP U-TDOA Response message. The U-TDOA Response message contains the physical channel information (frequencies, hopping sequence, channel type, time slot, sub-channel number, etc.), the intended Power-Up Starting Time (if the power-up procedure for U-TDOA is supported), the MS power, the cell identifier, and the TA. If frequency hopping is used, the U-TDOA Response message also includes the frequency list. The U-TDOA Response message also contains the ciphering key (Kc) if ciphering is used on the air interface and the version of the applied A5 ciphering algorithm (A5/x). The Kc is ciphered if sent from the SMLC to any LMU. The SMLC and any LMU with which it interacts shall also be mutually authenticated. These requirements shall be met using a security mechanism meeting the capabilities of the Zb interface of NDS/IP (TS 33.210) or TLS (RFC 2246). The LMU installation shall meet the same physical security requirements as a BTS installation. For locations on channels that are not ciphered, the algorithm identifier will show the same.
3. If the power-up procedure for U-TDOA is supported, the BSC may use the normal power-control command to order the MS to go to the maximum power allowed by the BTS. After the MS has been at full power for a period of one second, the BSC shall return to normal power-control. During the time the MS is ordered to the maximum power, the BSC may temporarily suspend uplink DTX, if in use.

9.5.1.3 RR Procedure effecting the CS U-TDOA channel description

The location determination process is not an instantaneous event and it can take a few seconds to collect and calculate location determination related data. If changes happen to the last reported channel description and the location determination is not complete, an updated channel description needs to be sent to the SMLC.

The BSC considers the location determinations complete if; it receives a BSSAP-LE Perform Location response message; or the delta timer expires; or it receives a valid BSSLAP message for a new positioning method.

The RR procedures that effect the U-TDOA channel description are listed in Table 9.5.1. The “Treatment” column lists the appropriate BSSLAP message to be sent by the BSC to the SMLC. The Reset message is defined in 3GPP TS 48.071 and shall contain the updated channel description. After sending the Reset message the BSC shall restart the delta timer and continue supervision of the location request.

Table 9.5.1: RR Procedures affecting the CS U-TDOA channel description

RR Procedure in Dedicated Mode	Treatment	Comments
Channel assignment procedure.	Reset	
Handover procedures (intra-BSS).	Reset	For successful intra-BSS handover.
Frequency redefinition procedure.	Reset	Only meaningful in the case of frequency hopping.
Packet request procedure while in dedicated mode.	Reset	For DTM, when an existing CS connection is modified as PS resources are added in order to comply with MS frequency/time domain restrictions.
Packet downlink assignment while in dedicated mode	Reset	For DTM, when an existing CS connection is modified as PS resources are added in order to comply with MS frequency/time domain restrictions.
Channel mode modify	Reset	

If the BSC receives the BSSLAP U-TDOA Request message during one of the identified RR procedures in Table 9.5.1, it will complete the ongoing RR procedure and then respond with the BSSLAP U-TDOA Response message.

9.5.1.4 BSC Error Handling during CS U-TDOA Positioning Procedure

There are three (3) BSSLAP messages defined to handle error scenarios that occur during the U-TDOA location process: Reset, Reject and Abort. Please refer to 3GPP TS 48.071 for the messages' details. The BSSLAP Reset message is used to update the U-TDOA channel description as outlined in 9.5.1.3.

In Table 9.5.2, all identified RR procedures are listed that result in the BSSLAP Abort message to be sent from the BSC to the SMLC. The Abort message is only sent if the U-TDOA location determination is not complete. The BSC considers the location determinations complete if; it receives a BSSAP-LE Perform Location response message; or the delta timer expires; or it receives a valid BSSLAP message for a new positioning method.

Table 9.5.2: RR Procedures resulting in BSC Error Handling

RR Procedure in Dedicated Mode	Treatment
Handover procedure (inter-BSS).	Abort
Handover to UTRAN procedure.	Abort
Handover to CDMA2000 procedure.	Abort
RR connection release procedure.	Abort

If the BSC receives the BSSLAP U-TDOA Request message during one of the identified RR procedures in Table 9.5.2, it will respond with the BSSLAP Abort message.

If the BSC is unable to perform the U-TDOA positioning for other reasons than those related to the items listed in Table 9.5.1 and Table 9.5.2, it will respond to the BSSLAP U-TDOA Request message with the BSSLAP Reject message.

9.5.2 U-TDOA Positioning in PS Domain for A/Gb-mode

9.5.2.1 Introduction

The U-TDOA location method uses information transmitted by an MS to make a location determination. The initial state of the MS will be identified and will dictate the procedure to be followed in the location process. If the MS was in the packet transfer mode, sending uplink RLC/MAC blocks prior to the beginning of the location process, the energy associated with this continuing uplink data can be used to locate the MS. If the MS was previously idle in the uplink direction and placed in the active state by the SGSN specifically for U-TDOA location determination purposes, it is necessary to cause the MS to send uplink information using the Packet polling procedure (see 3GPP TS 44.060).

An uplink block of data containing the PACKET CONTROL ACKNOWLEDGEMENT message is equivalent to any other RLC/MAC block for U-TDOA location purposes; i.e. one uplink RLC/MAC block is equivalent to one execution of the Packet polling procedure. This applies only to the lowest numbered timeslot in the case of a multi-slot uplink TBF. The Polling Repetition information element in the U-TDOA Request message defines the total number of RLC/MAC uplink blocks required to achieve the desired location QoS within a recommended period of two seconds, including any PACKET CONTROL ACKNOWLEDGEMENT message received due to the execution of a Packet polling procedure.

9.5.2.2 General Procedures

The U-TDOA location method procedures depend on the initial condition of the MS. If the MS is initially in packet idle mode the Packet Polling method shall be applied as described in sub-clause 9.5.2.2.1. When the MS is initially in the packet transfer mode it may or may not be sending uplink data. If the MS is not sending uplink data the Packet polling procedure shall be applied. The application of the U-TDOA location method in the packet transfer mode is described in sub-clause 9.5.2.2.2.

9.5.2.2.1 MS in packet idle mode

For an MS that is in packet idle mode, application of the U-TDOA location method requires that a single timeslot downlink TBF be established. This downlink TBF shall be used for repeated executions of the Packet polling procedure in order to cause a mobile to transmit for a time sufficient to achieve the requested level of location accuracy. The number of repetitions of the Packet polling procedure required to achieve the desired level of accuracy shall be indicated in the U-TDOA REQUEST message sent from the SMLC to the BSS.

The BSS shall execute the indicated number of Packet polling procedures after an implementation dependent interval to allow assignment of the Location Measurement Units (LMU) to the indicated ARFCN and timeslot(s). The RRBP field shall be used to schedule the resulting PACKET CONTROL ACKNOWLEDGEMENT messages. The BSS must indicate a PACKET CONTROL ACKNOWLEDGEMENT response containing the TLLI by setting the TYPE OF ACK information element to RLC/MAC control block in all PACKET POLLING REQUEST messages associated with U-TDOA positioning.

If the MS is allocated an uplink TBF prior to completion of the required number of Packet polling procedures, the BSS may suspend the Packet polling procedure and send a Reset message to the SMLC containing the physical channel information for the allocated uplink TBF. Following sending of a Reset message, the BSS shall reset the Polling Repetition counter to zero and restart the U-TDOA positioning procedure after an implementation dependent interval.

The downlink TBF established for U-TDOA location purposes should be used if a single timeslot downlink TBF is required during the execution of the U-TDOA location procedure. If a multi-slot downlink TBF is required during the execution of the U-TDOA location procedure, the assignment of this TBF may be delayed until the completion of the U-TDOA location procedure, otherwise the BSS shall send a Reset message to the SMLC and reset the Polling Repetition counter as described previously.

If both an uplink TBF and a downlink TBF are required during the execution of the U-TDOA location procedure, the Packet polling procedure may be restarted and the uplink RLC/MAC blocks can be used for U-TDOA location as described subsequently.

9.5.2.2.2 MS in packet transfer mode

If only a downlink TBF exists it shall be used to execute the Packet polling procedure, on the lowest numbered timeslot transmitted before the last PACKET POLLING REQUEST/PACKET CONTROL ACKNOWLEDGEMENT cycle has been completed, the BSS shall not set the FBI bit in the RLC/MAC header of the last data block. The TBF shall be terminated after the last cycle of the Packet polling procedure using a PACKET TBF RELEASE message from the BSS. If the MS is allocated an uplink TBF prior to completion of the required number of Packet polling procedures, the BSS may suspend the Packet polling procedure and send a Reset message to the SMLC as described in sub-clause 9.5.2.2.1.

If only an uplink TBF exists and RLC/MAC blocks are available for transmission (on the lowest numbered timeslot for a multi-slot TBF), those blocks shall be used to locate the MS using the U-TDOA location method. If the number of uplink blocks pertaining to the uplink TBF is insufficient to satisfy the requested number of uplink data blocks within an implementation dependent period recommended to be two seconds, the Packet polling procedure shall be executed on the existing uplink TBF for the balance of the requested blocks. The lowest numbered timeslot shall be used for the Packet polling procedure if the existing uplink TBF is a multi-slot TBF. The uplink TBF shall not be terminated until the Packet polling procedures have been completed.

If both an uplink and downlink TBF exist, either TBF may be used for MS location using the U-TDOA location method as described previously. The TBF should not be terminated until the Packet polling procedures have been completed.

9.5.2.3 PS U-TDOA Messages and Procedures on the Lb Interface

The following section describes the positioning procedure for PS U-TDOA location determination on the Lb interface.

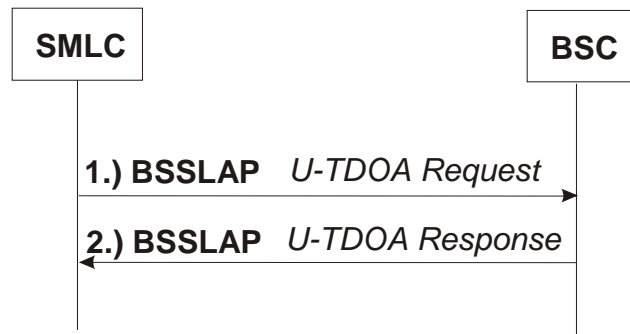


Figure 37: PS U-TDOA Positioning Procedure

1. The SMLC sends a BSSMAP-LE Connection Oriented Information message to the BSS that contains the embedded BSSLAP U-TDOA Request message. The U-TDOA Request message contains the required number of received uplink RLC/MAC blocks, repetitions of the RLC/MAC Packet polling request procedure or combination of both. The inclusion of this Polling Repetition information element in the U-TDOA Request message indicates that the location determination shall occur in the PS domain.
2. The BSS sends a BSSMAP-LE Connection Oriented Information message to the SMLC that contains the embedded BSSLAP U-TDOA Response message. The U-TDOA Response message contains; the physical channel information (frequencies, time slot, TFI, TLLI, start time, etc.); the MS power; the cell identifier; and the Timing Advance. For MS without an existing uplink or downlink TBF the BSS establishes a downlink TBF, if one does not currently exist. The BSS monitors any uplink TBF until the requested number of RLC/MAC blocks has been received, executes the specified number of Packet polling procedures on the lowest numbered timeslot in the case of a multi-slot TBF or a combination of both as described in clause 9.5.2.1. The BSS releases any downlink TBF established solely for U-TDOA location.

9.5.2.4 RLC/MAC Procedure affecting the PS U-TDOA TBF description

The RLC/MAC procedures that effect the U-TDOA channel description are listed in Table 9.5.3. The “Treatment” column lists the message to be sent by the BSS to the SMLC. The Reset message is defined in 3GPP TS 48.071 and shall contain the updated channel description. After sending the Reset message the BSS shall wait for an implementation dependent interval to allow reconfiguration of the LMUs, start the U-TDOA location process from the beginning and continue supervision of the location request.

Table 9.5.3: RLC/MAC Procedures affecting the PS U-TDOA channel description

RLC/MAC Procedure	Treatment	Comments
Packet Timeslot Reconfigure	Reset	
Packet Access Reject	Reset	Access retry cases
Cell Reselection	Reset	MS originated (intra-BSS)
Packet Cell Change Order	Reset	Network originated (intra-BSS)

If the BSS receives the BSSLAP U-TDOA Request message during one of the identified RLC/MAC procedures in Table 9.5.3, it will complete the ongoing RLC/MAC procedure and then respond with the BSSLAP U-TDOA Response message. The Reset message must be sent after completion of the listed RLC/MAC procedure if that procedure must be executed during an ongoing U-TDOA location event.

9.5.2.5 Error Handling during PS U-TDOA Positioning Procedure

In Table 9.5.4, all identified RLC/MAC procedures are listed that result in the BSSLAP Abort message to be sent from the BSS to the SMLC. The Abort message is only sent if the U-TDOA location determination is not complete. The BSS considers the location determinations complete if; it receives a BSSAP-LE Perform Location response message; or it receives a valid BSSLAP message for a new positioning method.

Table 9.5.4: RLC/MAC Procedures resulting in Error Handling

RLC/MAC Procedure	Treatment	Comments
Cell Reselection	Abort	MS originated (inter-BSS)
Packet Cell Change Order	Abort	Network originated (inter-BSS)
Packet Pause	Abort	
Packet Access Reject	Abort	Cases without access retry indication

If the BSS is unable to perform the U-TDOA positioning for other reasons than those related to the items listed in Table 9.5.3 and Table 9.5.4, it will respond to the BSSLAP U-TDOA Request message with the BSSLAP Reject message.

9.6 Multilateration Positioning Methods

9.6.1 General

Multilateration Positioning methods do not require the use of LMUs. For devices in PEO or EC operation (see 3GPP TS 43.064 [41]) two methods are supported: Multilateration Timing Advance (MTA) and Multilateration Observed Time Difference (MOTD). Based on assistance information from the BSS, targeted accuracy, MS capability and SMLC capability the SMLC decides which method to use, see sub-clause 9.6.2.2 below. When the MS is in idle mode the Core Network initiates the methods by indicating ‘paging for positioning’ as specified in sub-clause 9.1.3a. Both methods are only applicable for the PS domain in A/Gb-mode.

9.6.2 Multilateration Timing Advance

9.6.2.1 General procedure

This positioning method is based on one or more BSS acquiring Timing Advance (TA) information from a set of cells selected by the MS wherein the MS is triggered to perform MTA as a result of receiving an RRLP message from an SMLC indicating the MTA positioning method is to be used. The RRLP message may include network assistance information in order to facilitate and speed up the procedure, see sub-clause 9.6.2.4.2 for more details. Based on signal strength the MS autonomously selects a subset of the cells identified by the network assistance information (if any) to use for MTA. In addition, the MS may also select one or more additional cells not identified within assistance information the triggering RRLP message to perform MTA. In each of the selected cells the MS performs packet access for the BSS to be able to estimate a TA value for that particular cell. Three different methods are supported for the Timing Advance estimation.

- RLC data block method: This method supports Timing Advance Estimation for devices in both PEO and EC operation (CC1-CC4) wherein the MS sends an access burst on the (EC-)RACH and receives a corresponding single block allocation on the (EC-)AGCH for transmission of an RLC data block on a dedicated resource. The RLC data block contains MS accuracy related information and Source Identity of the serving cell see sub-clause 9.6.2.2. The method is suitable for Multilateration both cells internal to the serving BSS as well as for cells belonging to a non-serving BSS. For this method SMLC may indicate the MS to generate MTA Signature at the end of radio access part of MTA positioning procedure which can be used to verify the integrity of the location estimated from the MTA positioning method. Alternatively, for this method the SMLC may choose to direct the MS to include additional information in each RLC data block it sends during the MTA procedure, thereby allowing the serving BSS to verify the integrity of the location estimated from the MTA positioning method.
- Extended Access burst method: This method supports Timing Advance Estimation for devices in both PEO and EC operation (CC1 only) wherein the MS first sends an access burst and receives an assigned timing advance value within a corresponding Acknowledgement received on the (EC-)AGCH. It then sends an Extended Access Burst containing MS accuracy related information and a Short BSS ID that via configuration can be mapped to a serving BSS, see sub-clause 9.6.2.2. The method is suitable for both cells internal to the serving BSS as well as

for cells belonging to a non-serving BSS when the MS has been provided with a Short BSS ID in the triggering RRLP message.

- Access burst method: This method supports Timing Advance Estimation for devices in both PEO and EC operation wherein the MS sends an Access Burst on the RACH and receives an Acknowledgement on the (EC-)AGCH. The method is only suitable for cells internal to the serving BSS.

All TA estimations made by a BSS for any given MS performing MTA are relayed to the serving SMLC along with the identity of the reporting cell, the MS and BTS Accuracy thereby allowing the SMLC to estimate the position of the target MS.

9.6.2.2 Multilateration Timing Advance Request

The signalling flow is generic irrespective if the MS is in Packet Idle or Packet Transfer mode. If the MS is in Packet Idle mode, the Multilateration Timing Advance request procedure is performed subsequently to the paging for positioning procedure in sub-clause 9.1.3a. The signaling flow in Figure 38 below applies to integrated and standalone SMLCs in a packet switched network.

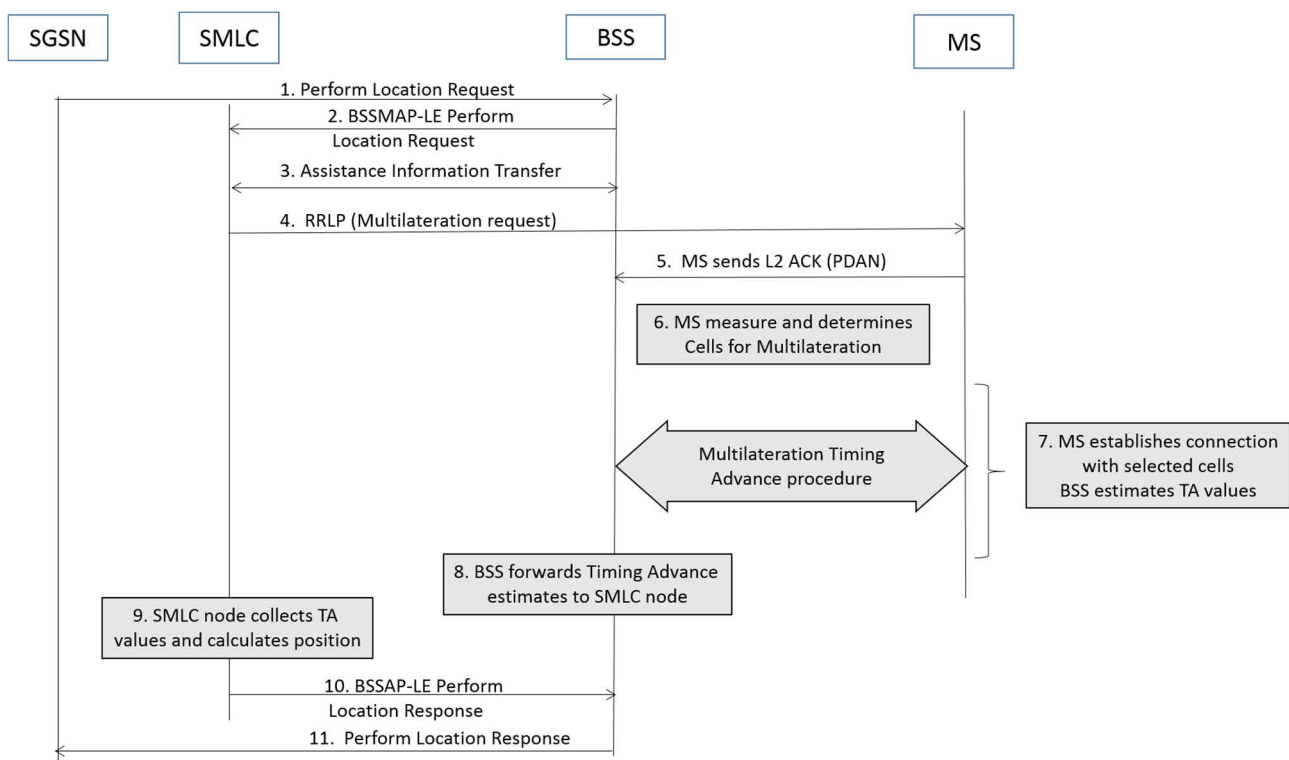


Figure 38: MTA positioning procedures in the PS domain

1. The SGSN sends a BSSGP PERFORM-LOCATION-REQUEST to the BSC serving the MS and includes, if available, the “Multilateration Timing Advance”, “MS Sync Accuracy” and “BTS Reception Accuracy Level”. If LLC ciphering is not activated at SGSN, the BSSGP PERFORM-LOCATION-REQUEST may indicate “MTA Access Security Required” if integrity protection for the radio access part of the MTA procedure is required.
2. The BSC sends to the SMLC a BSSMAP-LE Perform Location Request message that includes the “LCS capability”, the “BSS Multilateration Capability” and if available also the “Multilateration Timing Advance”, “MS Sync Accuracy”, “BTS Reception Accuracy Level” and an “MTA Access Security Required” indication if included in the BSSGP PERFORM-LOCATION-REQUEST received from the SGSN.
3. The SMLC may invoke the Assistance Information Transfer procedure to request Assistance Information from the serving BSS by sending to it a BSSMAP-LE Assistance Information Request message that includes a set of one or more cells for which assistance information is requested and optionally include a limited set of “Random ID” values (applies to Extended Access Burst method) or a set of “Short ID” values (applies to Access Burst method) associated with each cell for which it has requested Assistance Information. The serving BSS responds with a BSSMAP-LE Assistance Information Response message that contains the “Cell Information List” with

the per cell assistance information and the “BTS Reception Accuracy Capability”, see sub-clause 9.6.4.1 for more additional details. The serving BSS also includes “MTA Access Security Method Support” and/or “BSS Duplication Detection Method Support” in the BSSMAP-LE Assistance Information Response message.

4. To meet a targeted positioning accuracy the SMLC uses the “BTS Reception Accuracy Capability” as well as the “MS Sync Accuracy” as provided in the MSRAC IE (see 3GPP TS 24.008 [8]) to determine the number of targeted cells to be used in the MTA procedure and based on the serving cell it includes assistance data in an RRLP Multilateration Timing Advance Request message (see 3GPP TS 44.031 [15]) and sends the message to the MS (tunnelled via the BSS and the SGSN, see sub-step below and sub-clause 8.1a for the general description). If “MTA Access Security Required” is received from the BSS the SMLC decides if it should include an indication of (a) “MTA Access Security Method” in the RRLP Positioning Multilateration Timing Advance Request message if BSS includes “MTA Access Security Method Support” in the BSSMAP-LE Assistance Information Response message or (b) “BSS Duplication Detection Method” in the RRLP Positioning Multilateration Timing Advance Request message if the BSS includes “BSS Duplication Detection Method Support” in the BSSMAP-LE Assistance Information Response message.
 - 4a. The SMLC passes a BSSMAP-LE Connection Oriented Information message to the serving BSS containing an indication of the type of Multilateration method, a Multilateration Positioning Method timer and an embedded BSSLAP MS Position Command with an RRLP message parameter including the RRLP Positioning Multilateration Timing Advance Request message.
 - 4b. The BSS relays the embedded RRLP message, the RRLP flags IE and the MPM timer to the SGSN inside a BSSGP Position Command message. When the BSSGP Position Command message has been transferred, the BSS shall start a Multilateration supervision timer for the associated SCCP connection corresponding to the value indicated by the Multilateration Positioning Method timer field and upon expiry release the connection.
 - 4c. The SGSN receives the RRLP message in the BSSGP Position Command message and relays it to the MS in an LLC UI frame and includes a Positioning Event Indicator in the DL-UNITDATA PDU to indicate that the LLC PDU contains an RRLP Multilateration Timing Advance Request message (this is determined based on SGSN receiving a value for the MPM Timer in the BSSGP Position Command message). When the DL-UNITDATA PDU has been transferred the SGSN starts a supervision timer corresponding to the value indicated by the Multilateration Positioning Method timer for the associated MS and suspends downlink data delivery while the timer is running (see 3GPP 48.018 [25]).
5. The MS acknowledges reception of the RRLP MULTILATERATION REQUEST message on RR layer by means of a PDAN message and therein includes MS accuracy related information (“MS Sync Accuracy” and “MS Transmission Offset”). The BSS uses this PDAN transmission to estimate the timing advance applicable to the serving cell (i.e. a value used as the “Multilateration Timing Advance”) as well as the associated BTS Reception Accuracy Level before the MS leaves the serving cell. The “Multilateration Timing Advance” value as well as the “BTS Reception Accuracy Level” and “MS Sync Accuracy” are forwarded from the BSS to the SMLC (see 3GPP TS 45.010 [42]).
6. The RRLP application in the MS examines the RRLP Positioning Multilateration Timing Advance Request message and if assistance data is present it may use the assistance data to autonomously select which subset of these sets of cells it shall use to perform the radio access part of the MTA procedure. The MS may also select one or more additional cells not provided by the RRLP message.
7. The MS starts a supervision timer corresponding to the value indicated by timer contained in the RRLP message and sends an Multilateration access request indicating in each of the cells it selects for performing the Multilateration Timing Advance procedure.
 - New SI and EC-SI information shall indicate whether or not a cell supports the Multilateration Timing Advance procedure using either the RLC Data Block Transmission method, the Extended Access Burst method or the Access Burst method. This indication may also be included for each of the cells identified by the assistance information sent to the MS in the RRLP Multilateration message.
 - Information included within the RRLP Positioning Multilateration Timing Advance Request message indicates the MTA method is to be used when performing Multilateration Timing Advance for those cells (if they are used in the procedure). An MS in PEO operation shall perform the Multilateration Timing Advance procedure in a cell using the method indicated by the RRLP Positioning Multilateration Timing Advance Request message if (a) if the indicated method is supported by that cell, (b) the MS supports the indicated method and (c) the RRLP message provides sufficient assistance information for performing the indicated method in that cell. An MS that has enabled EC operation shall follow these same rules with the

restriction that the use of the Extended Access Burst method is limited to an MS in coverage conditions corresponding to CC1 or better.

- When performing the radio access part of the Multilateration Timing Advance procedure using the RLC Data Block method a MS sends a single MCS-1 coded RLC data block that conveys the MS identity (TLLI), "Source Identity" information (i.e. the "Cell Identity" and "Routing Area Identity" received in EC SI2/SI13 of the cell in which it was triggered to perform Multilateration), "MS Sync Accuracy", "MS Transmission Offset" (applicable to when it transmits the RLC data block) as well as a "Random ID" (see 3GPP TS 44.031 [15] and 3GPP TS 49.031 [22]). The RLC Data Block also includes "MTA Signature" if the MS is performing the radio access part of the MTA Procedure with the last cell selected for the MTA procedure and the "MTA Access Security Method" was indicated by the RRLP Positioning Multilateration Timing Advance Request message. If the "BSS Duplication Detection Method" was indicated by the RRLP Positioning Multilateration Timing Advance Request message each RLC Data Block sent by the MS during the MTA procedure includes a "MTA Report Instance" field and a "Final MTA Report Indicator" field. The RLC Data Block sent during the Multilateration Timing Advance procedure does not contain an LLC PDU. The BSS estimates the timing advance based on UL transmissions of the MS and adjusts the estimated timing advance value using the MS Transmission Offset (see 3GPP 45.010[42]).
 - When performing the Multilateration Timing Advance procedure using the Extended Access Burst method an MS sends an Extended Access Burst wherein the payload space supported by the set of two EC/EGPRS MULTILATERATION REQUEST messages used to perform the radio access part of the MTA procedure together convey the MS identity ("Short BSS ID" and "RandomID"), "MS Sync Accuracy" and "MS Transmission Offset" (applicable to when it transmits the Extended Access Burst). The BSS estimates the timing advance based on UL transmissions of the MS and adjusts the estimated timing advance value using the MS Transmission Offset (see 3GPP 45.010[42]).
 - When performing the radio access part of the Multilateration Timing Advance procedure using the Access Burst method an MS sends an access burst wherein the payload space conveys the MS identity (Short ID). The Access Burst method is only used for cells belonging to the serving BSS. The BSS estimates the timing advance based on an MS transmitting a single EC/EGPRS MULTILATERATION REQUEST on UL.
8. If the BSS has a context for the indicated MS Identity ("Short ID", "Random ID", or TLLI) i.e. it triggered the current Multilateration Timing Advance procedure for the indicated MS Identity it realizes it is the serving BSS and sends its default SMLC a "BSSMAP-LE Connection Oriented Information" message containing "Multilateration Timing Advance", "MS Sync Accuracy", "BTS Reception Accuracy Level", "Cell Identifier" and "Random ID" information. If the Access Burst method has been used only the "Multilateration Timing Advance" and "Short ID" are provided by the BSS to the SMLC. The BSS includes "MTA Signature" as part of the final BSSMAP-LE Connection Oriented Information to SMLC if available. If "MTA Signature" is included BSS also includes "MTA Sequence" which is generated by concatenation of Cell identifier and MS Transmission Offset parameters received from MS in each successful radio access part of the MTA procedure. If the BSS receives an "MTA Report Instance" and a "Final MTA Report Indicator" in a RLC Data Block received for the MTA procedure associated with the "Random ID" value also received in that RLC Data Block, it shall use them in an attempt to determine if a MTA reporting anomaly exists for that MTA procedure. If an anomaly is detected the BSS aborts the MTA procedure and informs the SMLC of the anomaly, thereby causing the SMLC to also abort that MTA procedure.

If the BSS has no context for the indicated MS Identity, it realizes it is a non-serving BSS and depending on which transport mechanism (CS or PS domain) is used to pass information to the serving BSS it proceeds as follows:

- a) CS Domain Used: The non-serving BSS sends the MSC a "BSSAP-LE Connectionless Information" message containing "Multilateration Timing Advance", "MS Sync Accuracy", "BTS Reception Accuracy Level" and "Random ID" parameters. The MSC then forwards the "BSSAP-LE Connectionless Information" message to the serving BSS (identified by the "Network Element Identity (target)" IE in the "BSSAP-LE Connectionless Information" message).
- b) PS Domain Used: The non-serving BSS sends the serving BSS a RAN-INFORMATION/Single Report (via the serving SGSN) containing "Multilateration Timing Advance", "MS Sync Accuracy", "BTS Reception Accuracy Level" and "Random ID" parameters (see 3GPP TS 48.018 [25]).

After receiving information from a non-serving BSS the serving BSS sends its default SMLC a "BSSMAP-LE Connection Oriented Information" message containing "Multilateration Timing Advance", "MS Sync Accuracy", "BTS Reception Accuracy Level", "Cell Identifier" and "Random ID" information.

9. For the RLC Data Block and Extended Access Burst methods, the serving SMLC then collects and validates all “Multilateration Timing Advance”, “BTS Reception Accuracy Level”, “MS Sync Accuracy” and “Cell Identifier” information associated with a given MS, for up to the length of the Multilateration Positioning Method timer after triggering the Multilateration Timing Advance procedure, using the provided “Random ID” parameter (see 3GPP TS 49.031 [22]).

For the Access Burst method the serving SMLC collects and validates all “Multilateration Timing Advance” information associated with a given MS, for up to the length of the Multilateration Positioning Method timer after triggering the Multilateration Timing Advance procedure, using the provided “Short ID” value.

If the SMLC receives an instance of MTA information from the BSS wherein either the value of “Random ID” or “Short ID” parameters has a value previously received for that MS for the ongoing MTA procedure the SMLC shall discard that instance of MTA information.

If the SMLC has included “MTA Access Security Method” IE in the RRLP message sent for a given MTA procedure and does not receive a corresponding “MTA Signature” from BSS, SMLC abandons the estimate of the MS location based on the received information from BSS and starts abnormal case handling procedure.

Using validated information, the SMLC then determines the MS location.

10. The SMLC then sends the serving BSS a “BSSMAP-LE Perform Location Response” message and includes the determined MS location information in the “Location Estimate” IE. The SMLC also includes “MTA Signature” and “MTA Sequence” in this message to SGSN, if it has received these IEs from BSS and has included “MTA Access Security Method” IE in the RRLP message sent for the corresponding MTA procedure.
11. The serving BSS sends the SGSN a “BSSGP PERFORM-LOCATION-RESPONSE PDU” message that includes the MS location information in the “Location Estimate” IE, “MTA Signature” IE and “MTA Sequence” IE if received from SMLC. The SGSN verifies the integrity of the location estimate by verifying the received MTA Signature against the Message Authentication Code (MAC) value derived based on the Integrity protection algorithm and keys associated with MS using “MTA Sequence” as MESSAGE [43].

9.6.2.3 Error Handling for MTA

- Case 1: When the SMLC sends the BSSAP-LE Connection Oriented Information message containing the RRLP Positioning Multilateration Timing Advance Request message to the BSS and the BSS cannot support the procedure it will send a BSSLAP reject message to the SMLC.
- Case 2: When the BSC forwards the RRLP Multilateration Timing Advance Request message in an BSSGP Position Command message (sent to the SGSN) the Multilateration supervision timer is started. After this, if the BSS determines that the current location procedure cannot be continued, the BSS sends an abort message to the SMLC. The determination that the MS has performed a reselection to a new cell is not a reason for the BSS to abort the procedure.
- Case 3: If the Multilateration supervision timer times out in the BSS before any “Multilateration Timing Advance”, “MS Sync Accuracy”, “BTS Reception Accuracy Level”, “Cell Identifier” and “Random ID” information for the target MS is sent to the SMLC, the BSS shall send a BSSLAP Abort to the SMLC. The location service attempt may then be restarted from the LCS Client, VMSC, or SGSN.
- Case 4: If the Multilateration supervision timer times out in the MS before the MS has been able to perform the Multilateration Timing Advance procedure to all selected cells the MS shall abort the procedure and return to idle mode.

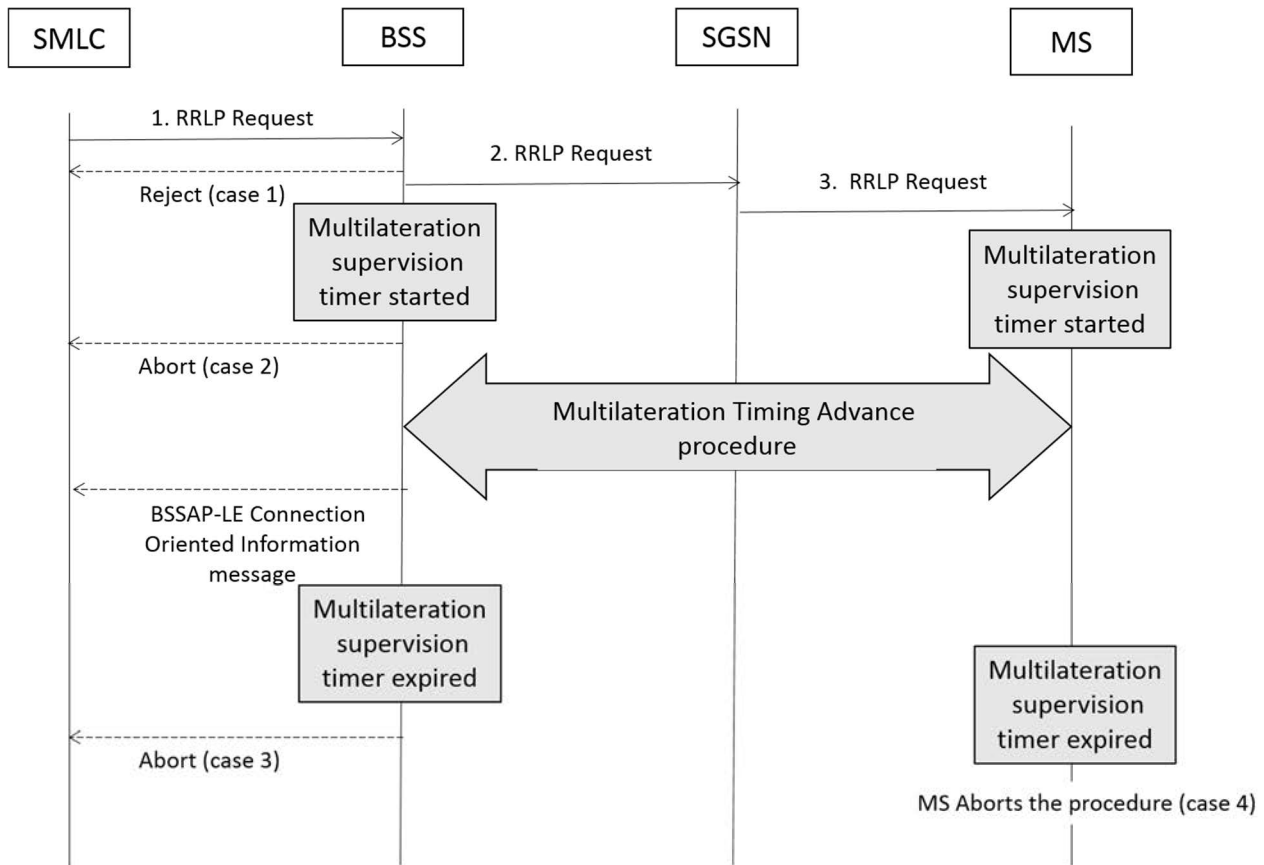


Figure 39: Error Handling for the MTA procedure in PS domain

9.6.2.4 Assistance Information

9.6.2.4.1 Assistance Information Transfer

The purpose of this procedure is for the SMLC to obtain assistance information from the serving BSS for subsequent inclusion in the RRLP Positioning Multilateration Timing Advance Request message sent from the SMLC to the MS to trigger the Multilateration Timing Advance procedure. In the procedure the SMLC sends to the serving BSS a BSSMAP-LE Assistance Information Request message containing the TLLI of the MS, a list of cells for which assistance information is requested and optionally a set of cell specific "Short ID" values assigned by the SMLC, and a limited set of "MTA Reference ID" values. The "Short ID" field specific to a given cell is included when the SMLC anticipates using the Access Burst method in that cell (if that cell is selected by the MS for performing MTA). Similarly, the limited set of "Random ID" values is included when the SMLC anticipates using Extended Access Burst method in that cell (if that cell is selected by the MS for performing MTA). The BSS responds with a BSSMAP-LE Assistance Information Response message and includes one or more instances of the (EC-)RACH control parameters/Coverage class thresholds (Coverage class thresholds are only provided if the serving BSS determines that the target MS is in EC operation) and BTS Reception Accuracy Capability applicable to the set of cells for which assistance information has been requested. The BTS Reception Accuracy Capability is used by the SMLC when determining the targeted number of cells to be selected by the MS in the Multilateration Timing Advance procedure.

9.6.2.4.2 Provisioning of Assistance Information to the MS

The MS is triggered to perform the Multilateration Timing Advance procedure through reception of a new RRLP Positioning Multilateration Timing Advance Request message (see 3GPP TS 44.031[15] sent by the SMLC where the MS is assumed to be in the best serving cell upon reception of the RRLP message. The RRLP Positioning Multilateration Timing Advance Request message may include network assistance information that consists of multiple sets of co-sited cells which the MS may take into account when performing the Multilateration Timing Advance procedure as well as cells co-sited with the serving cell which the MS shall avoid using when performing Multilateration Timing Advance procedure. The assistance information included in the RRLP Positioning

Multilateration Timing Advance Request message and may be generated by the SMLC using implementation specific methods or acquired from the serving BSS using the Assistance Information Transfer procedure, see sub-clause 9.6.4.1. Examples of additional assistance information include information about suitable neighbour cells, an indication of which of the indicated neighbour cells are co-sited cells, requested accuracy of the positioning procedure in the form of number of cells involved, the requested MS Sync Accuracy (see 3GPP TS 45.010 [42]), neighbour cell specific RACH/EC-RACH control/Coverage class parameters. The SMLC may also optionally provide an assignment of cell specific "Short ID" values (i.e. when the RRLP MTA message indicates Access Burst method is to be used), or a limited set of "Random ID" values (i.e. when the when the RRLP MTA message indicates Extended Access Burst method or RLC Data Block method is to be used) to be used during the TA estimation procedure (see 3GPP TS 49.031[22]). The MS autonomously selects the set of cells for performing the Multilateration Timing Advance procedure which may include a subset of the cells identified by the assistance information. The provisioning of assistance data improves the location accuracy for the Multilateration Timing Advance procedure and decreases the energy consumed in the MS to perform the positioning.

9.6.3 Multilateration OTD

9.6.3.1 General Procedure

This procedure uses MS measured observed time difference between serving cell and one or more neighbour cell and the timing advance reported by serving base station to estimate the position of the MS using multilateration. The observed time difference measurement is triggered at MS on reception of RRLP Multilateration OTD Request message containing measurement request for multilateration. The message may also include the network assistance information for OTD measurements such as list of co-sited neighbour cells and list of co-sited cells which share the same site as serving cell. On reception of the RRLP Multilateration OTD Request MS autonomously searches for best neighbour cell and after synchronisation with this cell it measures the time difference between TDMA frame timing of this neighbour cell and the serving cell. While selecting cell for OTD measurements the MS shall use the assistance information provided in the RRLP message to identify the co-sited cells and measures the OTD only for the best cell of the co-sited cells. In case the MS detects cell which is co-sited with serving cell the OTD measurement on this cell shall be skipped. After completion of OTD measurements with all the detected neighbour cells as per network assistance info or after measurement made on targeted number of cells provided in the measurement command, MS establishes TBF and sends RRLP measurement report for OTD multilateration. SMLC estimates the position of MS based on serving cell timing advance value reported from serving BSS and the OTD measurements reported from MS. The serving cell timing advance is estimated and reported to SMLC before MS leaves the serving cell for MOTD measurements. If the MS can find only cells of one neighbour cell site, it reports in addition to the OTD measurement of the best cell of the neighbour cell site also the received signal strength of all neighbour cells that it can receive. The Multilateration OTD procedure is only applicable for the PS domain in A/Gb-mode.

9.6.3.2 Multilateration Observed Time Difference Measurements

The Multilateration OTD is performed subsequently to the paging for positioning procedure described in sub-clause 9.1.3a. The signaling flow in Figure 40 below applies to integrated and standalone SMLCs in a packet switched network and is described below.

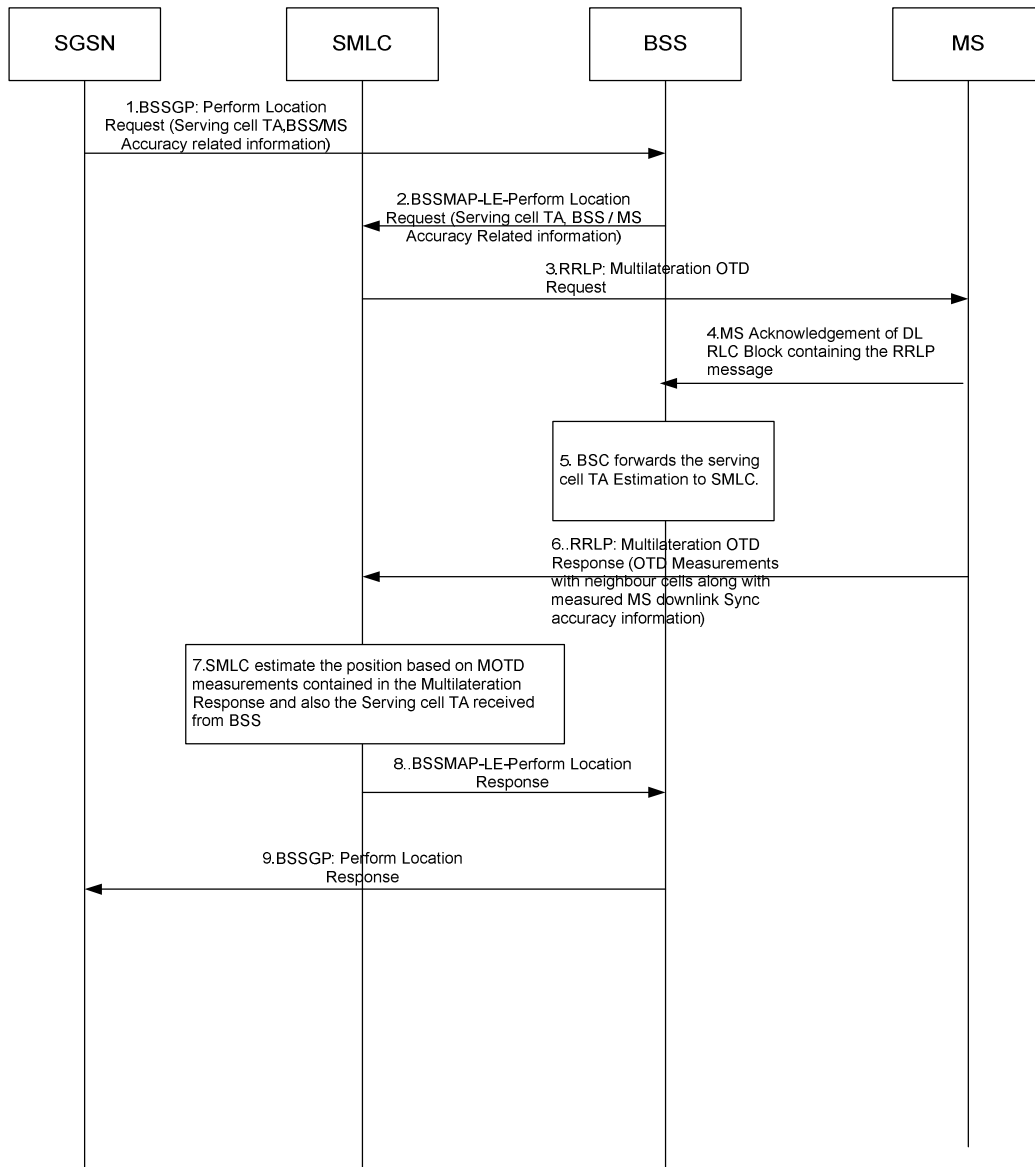


Figure 40: MOTD positioning procedure in the PS domain

1. The SGSN sends a BSSGP PERFORM-LOCATION-REQUEST to the BSC serving the MS. SGSN also includes the serving cell Timing advance, MS/BTS accuracy information in the message if available.
2. The BSC sends a BSSMAP-LE Perform Location Request message to the SMLC that includes the LCS capability IE and the BSS Multilateration Capability IE.
3. Based on the serving cell TA parameters reported, targeted MS position accuracy SMLC decides the Multilateration method to be used. The SMLC includes assistance data, if any, in an RRLP MULTILATERATION OTD REQUEST message and sends to the MS (tunnelled via the BSS and the SGSN, see sub-step below and sub-clause 8.1a for the general description).
 - 3a. The SMLC sends a BSSMAP-LE Connection Oriented Information message to the serving BSS containing an embedded BSSLAP MS Position Command with an RRLP message parameter including the RRLP MULTILATERATION OTD REQUEST message. SMLC includes the multilateration method and multilateration positioning timer information in this message.
 - 3b. The BSS relays the embedded RRLP message and the RRLP flags IE to the SGSN inside a BSSGP Position Command message. The BSS also includes the multilateration positioning timer information in this message which was received from SMLC.
 - 3c. The SGSN receives the RRLP message in the BSSGP Position Command message and relays it to the MS in an LLC UI frame. The SGSN starts the Multilateration positioning timer. SGSN does not send any downlink data towards MS while this timer is running. SGSN also includes additional parameter in the DL UNITDATA PDU which contains the RRLP message that the LLC PDU contains multilateration message.
- 4) The MS acknowledges the reception of the RRLP MULTILATERATION REQUEST message on RR layer by means of a PDAN message and therein includes MS accuracy related information (“MS Sync Accuracy” and “MS Transmission Offset”). The BSS uses this transmission to estimate the timing advance to the serving cell before the MS leaves the cell.
- 5) BSS sends the estimated timing advance along with BTS/MS accuracy related information to SMLC.
6. The RRLP application in MS receives the message and if it contains the network assistance information MS uses this information for selecting the neighbour cells for OTD measurements as part of its autonomous neighbour cell selection for OTD measurements. The RRLP message may also contain the targeted number of measurement reports.
 - 6a. MS synchronises to each of the detected neighbour cells and compares the TDMA frame timing of the neighbour cell with the TDMA frame timing of serving cell. The difference between the TDMA frame timing is considered as OTD of the neighbour cell with serving cell. MS uses the assistance information provided to select the neighbour cells for which OTD measurements are required.
 - 6b. MS also reports the downlink synchronisation accuracy of each cell along with each OTD measurement.
 - 6c. After completing the OTD measurements on required number of cells or on all the detected neighbour cell sites, MS sends the RRLP MULTILATERATION OTD MEASUREMENT RESPONSE message through serving cell. (For the special case that the MS can provide an OTD measurement for only one neighbour cell site, see subclause 9.6.1.1.)
- 7) SMLC receives the OTD measurement reports from MS via RRLP MULTILATERATION OTD MEASUREMENT RESPONSE. SMLC calculates the position of the MS based on timing advance of MS estimated at serving cell and the OTD measurements of neighbour cells.

NOTE: If the MS reports only one OTD measurement, the SMLC can perform only a bilateration. If the bilateration results in 2 intersections of 2 circles, the reported signal strength values of the neighbour cells can be used to determine which of these 2 possible MS locations is more plausible.

8. The SMLC then sends the serving BSS a “BSSMAP-LE Perform Location Response” message and includes the determined location information in the “Location Estimate” IE.
9. The serving BSS sends to the SGSN a “BSSGP PERFORM-LOCATION-RESPONSE PDU” message that includes the identified MS location in the “Location Estimate” IE.

9.6.3.3 Error Handling for MOTD

- Case 1: When the SMLC sends the BSSAP-LE Connection Oriented Information message containing the RRLP Multilateration OTD Request message to the BSS and the BSS cannot support the procedure it will send a BSSLAP reject message to the SMLC.
- Case 2: If the Multilateration supervision timer times out in SMLC before receiving the RRLP Multilateration OTD Measurement Response from MS SMLC aborts the procedure. Case 3: If the RRLP Multilateration OTD Measurement Response does not contain sufficient information for estimating the position, SMLC estimates the position based on serving cell ID +Timing advance and report this position in the Location Estimate IE.

9.6.3.4 Network Assistance Information for Multilateration OTD

The OTD measurements for multilateration can be optimised based on assistance information given from network as part of the Multilateration OTD measurement message. SMLC may include the list of co-sited cells at neighbour cell sites in the network assistance information which can be used by MS to optimise the OTD measurements among the co-sited cells. SMLC may also include the co-sited cells of serving base station as additional parameter. If the required positioning accuracy is known to SMLC, SMLC may also indicate the target number of measurement reports in the assistance information to optimise the MOTD measurements at MS. SMLC may also provide the requested downlink sync accuracy (see 3GPP TS 45.010) to MS as part of the assistance information.

10 Information storage

This clause describes information storage structures that are mandatory (M), conditional (C) or optional (O) for LCS in GERAN, and the recovery and restoration procedures needed to maintain service if inconsistencies in databases occur and for lost or invalid database information.

10.1 SMLC

Common Data

Table 2 holds permanent BTS data:

Table 2: Permanent SMLC Data for a BTS

Permanent BTS Data Item	Status	Description
BTS position	M	BTS position (latitude/longitude) of the Serving BTS
CGI	M	Cell global identity.
BSIC	M	Base station identity code.
BCCH	M	Frequency of the broadcast carrier.

The SMLC holds data for its associated LMUs. The main key to LMU data in the SMLC is the IMSI for a Type A LMU and a cell site identifier for a Type B LMU. LMU data provides the location capabilities of the LMU (e.g. which location and assistance measurements are supported). The following permanent data shall be administered for any LMU.

Table 3: Permanent SMLC Data for an LMU

Permanent LMU Data Item	Status	Description
Type of LMU	M	Indicates if LMU is Type A or Type B
IMSI	C	Main key to data for a Type A LMU. Not applicable to a Type B LMU
LAC + CI	C	Cell site identifier to address a Type B LMU. Not applicable to a Type A LMU.
Signaling Access	M	Information regarding signalling access to the LMU including the following: <ul style="list-style-type: none"> - address of default serving BSC - SS7 link set to serving BSC (or to an intermediate STP)
Serving Cell	M	Identity of the cell in which the LMU is physically located
Geographic location	C	Latitude/longitude coordinates Storage of coordinates is mandatory for E-OTD if an LMU is not co-located with a BTS
Position measurement functions	O	List of supported position measurements For each type of position measurement, a list of associated capabilities – details are outside the scope of the present document
Assistance measurement functions	O	List of supported assistance measurements For each type of assistance measurement, a list of associated capabilities – details are outside the scope of the present document
Diagnostic functions	O	List of supported diagnostic functions – details are outside the scope of the present document

The SMLC also holds the following temporary data for each LMU for which there has been any previous signalling interaction.

Table 4: Temporary SMLC Data for an LMU

Temporary LMU Data Item	Status	Description
Position Measurements	O	Ongoing and scheduled position measurements ordered in the LMU by the SMLC – details are outside the scope of the present document
Assistance Measurements	O	Ongoing and scheduled assistance measurements ordered by the SMLC – details are outside the scope of the present document
O&M Activities	O	Ongoing and scheduled O&M activities ordered in the LMU by the SMLC – details are outside the scope of the present document

An LMU contains no mandatory data regarding its associated SMLC. An LMU shall contain permanent data regarding its measurement and O&M capabilities and may contain pre-administered data regarding location assistance measurements and O&M activities that the LMU is to perform without the need for any command from the SMLC. The content of such location measurement and O&M related data is outside the scope of the present document.

10.2 Recovery and Restoration Procedures

The LCS recovery and restoration procedures allow temporary data to be recovered or re-initialized following loss or corruption of data, such that normal LCS service is rapidly restored and inconsistency between the data held by different LCS network elements is removed. For a full description, refer to 3GPP TS 23.007 [4].

Annex A (informative): Change history

Change history							
Date	TSG GERAN#	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2001-04	04	GP-010942			Version for Release 4		4.0.0
2001-06	05	GP-010988	001		LCS error handling (Inter-BSC Handover)	4.0.0	4.1.0
2001-06	05	GP-011308	007		Geographic Shape Restriction	4.0.0	4.1.0
2001-08	06	GP-011935	010	2	Correct Faulty References to the BSSAP-LE and RR Specifications	4.1.0	4.2.0
2001-08	06	GP-011905	011		Update of GERAN LCS Stage 2 for Release 5	4.2.0	5.0.0
2001-11	07	GP-012836	012	3	Inter NSE Cell Change for LCS for GPRS	5.0.0	5.1.0
2001-11	07	GP-011993	014		Clean-up CR for LCS for GPRS	5.0.0	5.1.0
2001-11	07	GP-011998	016		Correction of Inconsistent Text	5.0.0	5.1.0
2001-11	07	GP-012210	018		Error Handling for E-OTD and GPS	5.0.0	5.1.0
2001-11	07	GP-012822	019	1	Use of TOM signaling to support LCS for Gb Mode	5.0.0	5.1.0
2001-11	07	GP-012280	021		Editorial revision definition section for TS 43.059	5.0.0	5.1.0
2002-02	08	GP-020039	023		TOM Protocol Header Definition for LCS for GPRS	5.1.0	5.2.0
2002-02	08	GP-020437	025	1	Informing an SMLC of a change in the LAC for LCS using BSSLAP	5.1.0	5.2.0
2002-02	08	GP-020493	026	2	Stage 2 Updates for Iu Mode LCS	5.1.0	5.2.0
2002-04	09	GP-021215	027	1	Corrections to LCS Stage 2 for Release 5	5.2.0	5.3.0
2002-04	09	GP-020621	028		Inclusion of PTP BVCI for Positioning Procedure over the Gb Interface	5.2.0	5.3.0
2002-04	09	GP-021127	030	1	Correction of timing when SMLC enters LOCATION state	5.2.0	5.3.0
2002-04	09	GP-021225	031	2	LCS Stage 2 Corrections	5.2.0	5.3.0
2002-04	09	GP-020998	032		Correction of MS-SMLC Information Transfer Description	5.2.0	5.3.0
2003-04	14	GP-031064	037	8	Inclusion of U-TDOA location method	5.3.0	6.0.0
2003-06	15	GP-031657	038	1	Inclusion of RR Procedures and enhancement of the Reset procedure for U-TDOA	6.0.0	6.1.0
2003-11	17	GP-032501	042		Inclusion of Channel Mode Modify RR Procedures for U-TDOA calls	6.1.0	6.2.0
2004-04	19	GP-040634	043	3	Removal of emergency services client type restriction for the U-TDOA location method	6.2.0	6.3.0
2004-04	19	GP-040683	050	1	Alignment of GERAN location request procedure to UTRAN	6.2.0	6.3.0
2004-11	22	GP-042330	051	9	Inclusion of PS functionality for U-TDOA location method	6.3.0	6.4.0
2004-11	22	GP-042701	054	1	Correction to add U-TDOA reference to Cell Change for the PS Domain sub-clause	6.3.0	6.4.0
2005-04	24	GP-050766	055		Enabling the Providing of Velocity	6.4.0	7.0.0
2005-06	25	GP-051778	059	1	Providing IMSI and IMEI to the SMLC in positioning procedures	7.0.0	7.1.0
2006-04	29	GP-060928	0064	1	Correction of State Update Procedure	7.1.0	7.2.0
2006-04	29	GP-060870	0068	1	Inclusion of Support for SIGTRAN on Lb-interface	7.1.0	7.2.0
2006-04	29	GP-060984	0069	4	Introduction of A-GNSS	7.1.0	7.2.0
2007-05	34	GP-070780	0071		Addition of Positioning Capability Transfer using RRLP	7.2.0	7.3.0
2007-11	36	GP-072003	0072	6	U-TDOA Enhancement WI modification to procedure for receipt of U-TDOA Request message	7.3.0	8.0.0
2008-08	39	GP-081345	0075	1	Support for additional navigation satellite systems	8.0.0	8.1.0
2009-11	44	GP-092337	0076	5	Changes to Stage II allowing Parallel positioning	8.1.0	9.0.0
2011-03	49				Version for Release 10	9.0.0	10.0.0
2012-09	55				Version for Release 11	10.0.0	11.0.0
2014-02	61	GP-140195	0078	1	Introduction of BDS in GERAN	11.0.0	12.0.0
2015-12	68				Version for Release 13	12.0.0	
2016-02	69	GP-160154	0079	1	Introduction of eDRX and EC-EGPRS	13.0.0	13.1.0

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2016-05	RP-70	GP-160311	0080	-	F	Miscellaneous corrections related to EC-GSM-IoT	13.2.0
2017-03	RP-75	RP-170060	0081	8	B	Introduction of Multilateration	14.0.0
2017-03	RP-75	RP-170060	0082	3	B	Introduction of Multilateration OTD	14.0.0
2017-06	RP-76	RP-170923	0084	3	F	Multilateration - Miscellaneous corrections	14.1.0
2017-09	RP-77	RP-171597	0087	-	A	Removal of references to TS 44.118	14.2.0
2018-03	RP-79	RP-180068	0088	1	B	Security Enhancement for MTA in network configuration without LLC security	15.0.0
2018-06	RP-80	RP-180822	0089	-	F	Editorial corrections to Security Enhancement for MTA in network configuration without LLC security	15.1.0
2020-07	RP-88e	-	-	-	-	Upgrade to Rel-16 version without technical change	16.0.0
2022-03	RP-95e	-	-	-	-	Upgrade to Rel-17 version without technical change	17.0.0

History

Document history		
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