TSG-RAN Meeting #28
Quebec, Canada, 01-03 June 2005

RP-050330
agenda item 8.3.1

Source: **TSG-RAN WG2.**

Title: **Inclusion of Uplink TDOA UE positioning method in the UTRAN specifications**

The following CR is in RP-050330

Spec	CR	Rev	Phase	Subject	Cat	Version-Current	Version-New	Doc-2nd-Level	Workitem
25.305	0105	-	Rel-7	Addition of the U-TDOA location method to the UTRAN	B	6.1.0	7.0.0	R2-051686	LCS3-UEPos-UTDOA

CR-Form-v7.1

CHANGE REQUEST

⌘ **25.305** **CR** **0105** ⌘ **rev** **-** ⌘ Current version: **6.1.0** ⌘

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.*

Proposed change affects: UICC apps⌘ ☐ ME ☐ Radio Access Network **X** Core Network ☐

Title:	⌘	Addition of the U-TDOA location method to the UTRAN
Source:	⌘	RAN WG2
Work item code:	⌘	LCS3-UEPos-UTDOA
Date:	⌘	09/05/2005
Category:	⌘	**B**
Release:	⌘	Rel-7

Use one of the following categories:
F *(correction)*
A *(corresponds to a correction in an earlier release)*
B *(addition of feature),*
C *(functional modification of feature)*
D *(editorial modification)*
Detailed explanations of the above categories can be found in 3GPP TR 21.900.

Use one of the following releases:
Ph2 (GSM Phase 2)
R96 (Release 1996)
R97 (Release 1997)
R98 (Release 1998)
R99 (Release 1999)
Rel-4 (Release 4)
Rel-5 (Release 5)
Rel-6 (Release 6)
Rel-7 (Release 7)

Reason for change:	⌘	Addition of U-TDOA positioning method in UTRAN and optional SAS location method selection
Summary of change:	⌘	Add messaging to the PCAP on the Iupc interface which supports the U-TDOA location method and SAS location method determination
Consequences if not approved:	⌘	Existing 2G network operators currently utilizing the U-TDOA location method will not have an upward migration path for their UTRAN networks

Clauses affected:	⌘	3.2, 4.3, 5.1, 5.2.1, 5.2.3, 5.2.5, 6.6.5, 7.3.1, 7.3.4, 7.4.1, 8, 8.1, 9.6.1, 9.6.2, 10.6, 10.7, 12, Annex B

	Y	N		
Other specs affected: ⌘		X	Other core specifications	⌘
		X	Test specifications	
		X	O&M Specifications	

Other comments:	⌘	SAS and RNC centric versions of U-TDOA are defined in this CR as well as SAS versions of other positioning methods (A-GPS, OTDOA, cell ID-RTT). The inclusion of SAS centric positioning provides extra support for combining different positioning methods (e.g. hybrid positioning) because with either version of U-TDOA (RNC centric or SAS centric), only the SAS has access to complete LMU measurement information.

[First Changed Section]

3.2 Abbreviations

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

3G-MSC	3rd Generation MSC
3G-SGSN	3rd Generation SGSN
A-GPS	Assisted Global Positioning Systems
ARIB	Association of Radio Industries and Business
CAMEL	Customised Application For Mobile Network Enhanced Logic
CN	Core Network
CRNC	Controlling RNC
DGPS	Differential Global Positioning Systems
DL	Downlink
DRNC	Drift RNC
GMLC	Gateway MLC
GPRS	General Packet Radio System
GPS	Global Positioning System
HLR	Home Location Register
IPDL	Idle Period Downlink
LBS	Location Based Services
LCCF	Location Client Control Function
LCF	Location Client Function
LCS	LoCation Services
LIRF	Location Information Relay Function
LMU	Location Measurement Unit
LSADF	Location System Assistance Data Function
LSCF	Location System Control Function
LSCFS	Location System Control Function in SAS
LSOF	Location System Operation Function
MLC	Mobile Location Centre
MSC	Mobile services Switching Centre
NAS	Non Access Stratum
OTDOA	Observed Time Difference Of Arrival
PCAP	Positioning Calculation Application Part
PCF	Position Calculation Function
PLMN	Public Land Mobile Network
PRCF	Positioning Radio Co-ordination Function
PRComF	Positioning Radio Communication Function
PRRM	Positioning Radio Resource Management
PSMF	Positioning Signal Measurement Function
QoS	Quality of Service
RAN	Radio Access Network
RANAP	Radio Access Network Application Part
RNC	Radio Network Controller
RRM	Radio Resource Management
RTD	Real Time Difference
RTT	Round Trip Time
SAI	Service Area Identifier
SAS	Stand-Alone SMLC
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module
SMS	Short Message Service
SRNC	Serving RNC
SSDT	Site Selection Diversity Transmit
TOA	Time Of Arrival
TOW	Time Of Week
U-…..	UMTS-(LCS functional block)
UE	User Equipment

UL	Uplink
UMTS	Universal Mobile Telecommunication System
USIM	User Service Identity Module
UTC	Universal Time Coordinates
U-TDOA	Uplink – Time Difference Of Arrival
UTRAN	Universal Terrestrial Radio Access Network
WCDMA	Wideband Code Division Multiple Access

[Next Changed Section]

4.3 Standard UE Positioning Methods

The standard positioning methods supported within UTRAN are:

- cell ID based method;
- OTDOA method that may be assisted by network configurable idle periods;
- network-assisted GPS methods;
- U-TDOA.

[Next Changed Section]

4.3.4 U-TDOA Method

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

The operation of the U-TDOA location method is described in clause 12.

[Next Changed Section]

5.1 UE Positioning Operations

The schematic functional description of LCS operations in UMTS is defined in [13].

Upon request from the Core Network or for internal operations, a ~~RNC~~ UTRAN UE Positioning function should:

- request measurements, typically from the UE and one or more Node B;
- send the measurement results to the appropriate calculating function within UTRAN;
- receive the result from the calculating function within UTRAN;
- perform any needed co-ordinate transformations;
- send the results to the LCS entities in the CN or to application entities within UTRAN (this function applies to the RNC only).

In the event that the client is internal to UTRAN the request may be made directly to the UTRAN UE Positioning entities as the internal clients are considered to be "pre-authorised".

As part of its operation, the UTRAN UE Positioning 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 UTRAN UE Positioning 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 positioning information directly, or may be able to supply auxiliary information to the calculation function. The UTRAN UE Positioning co-ordination function, as part of its activity to supervise the positioning process, may query the UE or other elements of the UTRAN 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 5.2. This figure is not intended to show the complete UE Positioning operation for UTRAN, but to simply to outline the basis for operation.

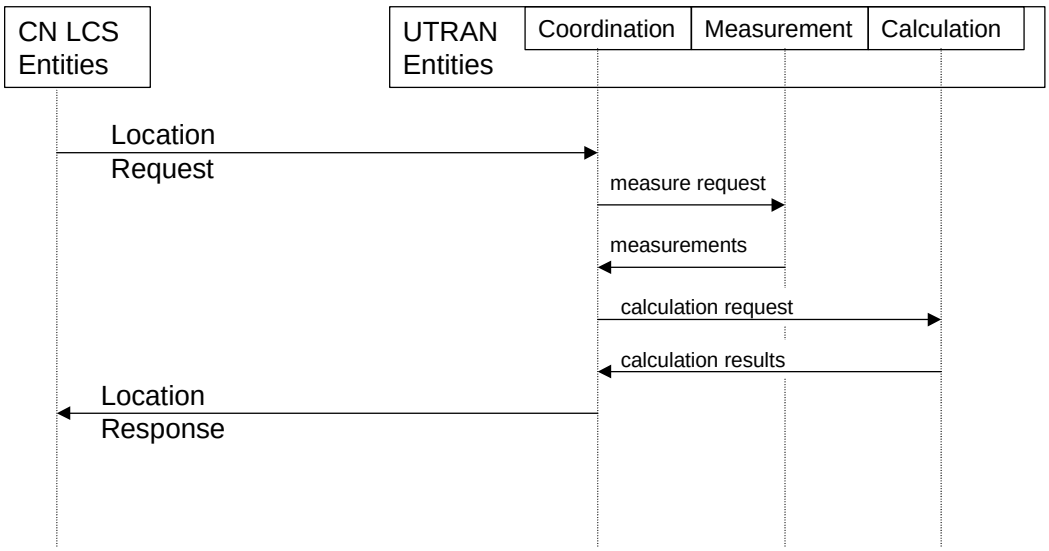

Figure 5.2: General sequence for UE Positioning operation

[Next Changed Section]

5.2 Functional Description of UTRAN UE Positioning related elements

5.2.1 Radio Network Controller (RNC)

5.2.1.1 Serving RNC

The SRNC is a network element of UTRAN and contains functionality required to support LCS in one PLMN. The SRNC can work either in the RNC centric mode or in a SAS centric mode where the SAS has control over the positioning procedures.

5.2.1.1.1 RNC Centric Mode

In RNC centric mode ~~T~~the SRNC provides the following functionality:

- request of information from other RNC:
  The SRNC may request information regarding UE Positioning from other RNCs;

- flow control of positioning requests:
  If several simultaneous positioning requests are present within one SRNC, the SRNC co-ordinates the positioning requests taking into account priority of the requests (e.g. for Emergency Clients);

- positioning method selection:
  The positioning method selection is based on the location request, QoS, capabilities of UE Positioning elements and UE positioning capabilities

- position calculation:
  The SRNC may calculate the position of a UE and may also support conversion of the position estimate between different geographic reference systems. In case RNC estimates the UE position, it is also responsible to estimate the accuracy of the position estimate. This accuracy estimate should include, for example, the effect of geometric dilution of precision (GDOP), the capabilities of the signal measuring hardware, the effects of multipath propagation and the effects of timing and synchronisation unknowns. The accuracy should be returned as a measure of distance in the same units as the position estimate. The accuracy zone may be reported as the axis and orientation of an ellipse surrounding the position estimate. If available, the positioning method (or the list of the methods) used to obtain the position estimate may also be returned to the CN with the position information. If the CN has requested an accuracy for the position estimate, the Location response shall include an indication whether the position estimate satisfies the requested accuracy or not.

- provide UE Positioning assistance data:
  The SRNC may provide assistance data in the support of the various positioning methods;

- Overall UE Positioning coordination and control:
  If both an SAS and an SRNC with SMLC internal functionality are available, the SRNC is responsible for the overall coordination and control of UE Positioning. For example, although the SAS has a position calculation function, the SRNC may also have a position calculation function. The SRNC is responsible for managing the co-ordination and control of these multiple resources.

The SRNC, of course, also provides CRNC functionality regarding UE Positioning for its associated Node Bs and LMUs.

5.2.1.1.2 SAS Centric Mode

In SAS centric mode the SRNC provides the following functionality:

- Forwarding of location requests to the SAS:

  The SRNC forwards incoming location requests to the SAS and provides further information like UE capabilities and UE Cell ID to guide the positioning method selection in the SAS

- Forwarding of UE positioning assistance data and measurement instructions

  Upon request from the SAS, the SRNC forwards assistance data and/or measurement instructions from the SAS to the UE in support of the various positioning methods.

- Delivery of positioning information

  Upon request from the SAS the SRNC gathers location related information from the NodeBs and the UE and sends this information back to the SAS.

- Forwarding of positioning estimates

  The SRNC forwards the positioning result received from the SAS to the requesting CN entity.

[Next Changed Section]

5.2.3 Location measurement unit (LMU)

Location Measurement Units (LMU) are associated with either the CRNC or the SAS. LMUs associated with the SAS are outside the scope of this specification.

The Location Measurement Unit (LMU) entity makes measurements (e.g. of radio signals) and communicates these measurements to a RNC. The LMU may also perform calculations associated with the measurements.

All positioning and assistance measurements obtained by an LMU are supplied to a particular CRNC associated with the LMU. Instructions concerning the timing, the nature and any periodicity of these measurements are either provided by the CRNC or are pre-administered in the CRNC (e.g. using O&M).

The LMU may make its measurements in response to requests (e.g. from the CRNC), or it may autonomously measure and report regularly (e.g. timing of Node B transmissions) or when there are significant changes in radio conditions (e.g. changes in the UTRAN GPS timing of cell frames or SFN-SFN Observed Time Difference).

There may be one or more LMU associated with the UTRAN and an UE Positioning request may involve measurements by one or more LMU. The LMU may be of several types and the CRNCs will select the appropriate LMUs depending on the UE Positioning method being used.

The LMU may be used, for example, to measure UTRAN transmissions either UL or DL. These measurements may be made either, for example, to locate the UE or to measure a system parameter needed by the UE Positioning such as the timing offset (UTRAN GPS timing of cell frames or SFN-SFN Observed Time Difference) of transmissions Node Bs. The LMU may also measure other transmissions, such as those of satellite navigation systems (i.e. GPS) and either report the measurements for use by the CRNC, or report the positioning results as determined by internal calculations of the LMU. The details of the measurements to be made by the LMU will be defined by the chosen UE Positioning method.

An LMU makes radio measurements to support one or more positioning methods. These measurements fall into one of two categories:

(a) positioning measurements specific to one UE and used to compute its position;

(b) assistance measurements applicable to all UEs in a certain geographic area.

There are two classes of LMU:

- **Stand-Alone LMU:** communicates with RNCs via the Uu interface;
- **Associated LMU:** communicates with RNCs via the Iub interface.

The associated LMU signalling protocol is the NBAP. The protocol for stand-alone LMU UTRAN signalling will be the RRC protocol.

Stand-Alone LMU

A stand-alone LMU is accessed exclusively over the UTRAN air interface (Uu interface). There is no other connection from the stand-alone LMU to any other UTRAN network element.

NOTE 1: This does not preclude a stand-alone LMU from also communicating with other access networks (e.g. GSM) through interfaces that are not part of the present document.

A stand-alone LMU has a serving Node B that provides signalling access to its CRNC. A stand-alone LMU also has a serving 3G-MSC, VLR and a subscription profile in an HLR. A stand-alone LMU always has a unique IMSI and supports all radio resource and mobility management functions of the UTRAN radio interface that are necessary to support signalling. A stand-alone LMU shall support those connection management functions necessary to support UE Positioning signalling transactions with the CRNC and may support certain call control functions of to support signalling to an CRNC using a circuit switched data connection.

NOTE 2: A network operator may assign specific ranges of IMSI for its LMUs and may assign certain digits within the IMSI to indicate the associated CRNC. Certain digits in the IMSI may also be used as a local identifier for an LMU within an CRNC.

To ensure that a Stand-alone LMU and its associated CRNC can always access one another, an LMU may be homed (camped) on a particular cell site or group of cell sites belonging to one 3G-MSC. For any Stand-alone LMU with a subscription profile in an HLR, a special profile may be used to indicate the assigned supplementary services (e.g. the SMS-PP MT for data download via the SIM application toolkit, and barring of all incoming and possibly outgoing calls). An identifier in the HLR profile also distinguishes an LMU from a normal UE. All other data specific to an LMU is administered in the LMU and in its associated CRNC.

Associated LMU

An associated LMU is accessed over the Iub interface from an RNC. An associated LMU may make use of the radio apparatus and antennas of its associated Node B. The LMU may be either a logically separate network element addressed using some pseudo-cell ID, or connected to or integrated in a Node B. Signalling to an associated LMU is by means of messages routed through the controlling Node B.

An associated LMU may be separated from the Node B, but still communicate with the CRNC via the Node B Iub interface. The interface between the associated LMU and its Node B is not part of the present document.

NOTE 3: An associated LMU is not precluded from also communicating with other access networks (e.g. GSM) through interfaces that are not part of the present document.

Measurements

The assistance measurements obtained by an LMU are generic and are usable by more than one positioning method. These include:

- **Radio Interface Timing measurements:** include UTRAN GPS timing of cell frames or SFN-SFN Observed Time Difference of the signals transmitted by Node B, where timing differences are measured relative to either some common reference clock (UTRAN GPS timing of cell frames) or the signals of another Node B (SFN-SFN Observed Time Difference);

- **Inter-System Timing measurements:** include timing measurements between the UTRAN radio signals transmitted by a Node B and an external system such as the GPS or GSM.

[Next Changed Section]

5.2.5 Stand-alone SMLC

An SAS performs one or more of the following procedures:

- Provide GPS assistance data to the RNC, for both UE-assisted and UE-based method types, to be delivered through point-to-point or broadcast channels to UE;

- Act as a location calculation server if the location estimates are not to be calculated in the RNC;

- Performs a U-TDOA positioning of a particular UE on request of the SRNC.

- Optionally, the SAS may determine the most appropriate positioning method or combination of positioning methods. When the SAS location method determination option is seleted:

    - The SAS is responsible to select the set of GPS assistance data to be sent to the UE for A-GPS based positioning and provide that assistance data to the SRNC within the PCAP Position Activation Request message;

    - The SAS is responsible to request UE positioning related information from the SRNC, e.g. channel information or round trip time;

    - The SAS is responsible for coordination of simultaneous UE positioning requests from the CN.

- Selecting the set of U-TDOA capable LMUs to be involved in a U-TDOA location determination;

The SAS communicates with the RNC over the Iupc interface enabling it to forward UE Positioning assistance data to UEs and to receive UE Positioning measurement data from the RNC.

When timing assistance is needed, the SAS may rely~~ies~~ on associated LMUs or on the RNC (and on the possibility to have GPS receivers co-located with the RNC, the Node Bs and/or present in the UEs) to obtain that.

[Next Changed Section]

6.6.5 Iupc Interface

UE Positioning operations on the Iupc interface are described in [27]. That specification defines in more detail the procedures needed for messages for the UE positioning method.

The Iupc interface is used to allow communication between an RNC and an SAS. This interface is used to signal position estimate requests and responses as well as UE Positioning related information using mechanisms consistent with the other internal UTRAN interfaces. The Iupc interface is used for providing the RNC with UE Positioning data to be used for both point-to-point and broadcast purposes. The Iupc interface uses an Iups-like protocol stack for the transport layer which is described in [28].

6.6.5.1 Signalling between RNC and SAS

The signalling between RNC and SAS is done by using PCAP procedures specified in [27].

6.6.5.1.1 PCAP Position Calculation

The PCAP Position Calculation message flow illustrates how an SRNC invokes an SAS to calculate a position estimate of a UE.

The SRNC initiates the PCAP Position Calculation message flow in the RNC centric mode for UEs that support the following positioning method types:

- UE assisted;
- UE assisted is preferred, but UE based is allowed;
- UE based is preferred, but UE assisted is allowed;

when the chosen positioning method type is 'UE Assisted'.

For UEs that only support the UE based positioning method or that, supporting both, have selected the 'UE Based' option, the PCAP Position Calculation message flow is not applicable.

The SRNC also inititates the PCAP Position Calculation message flow to invoke the U-TDOA positioning method in the case that U-TDOA is initiated from the SRNC and not from the SAS.

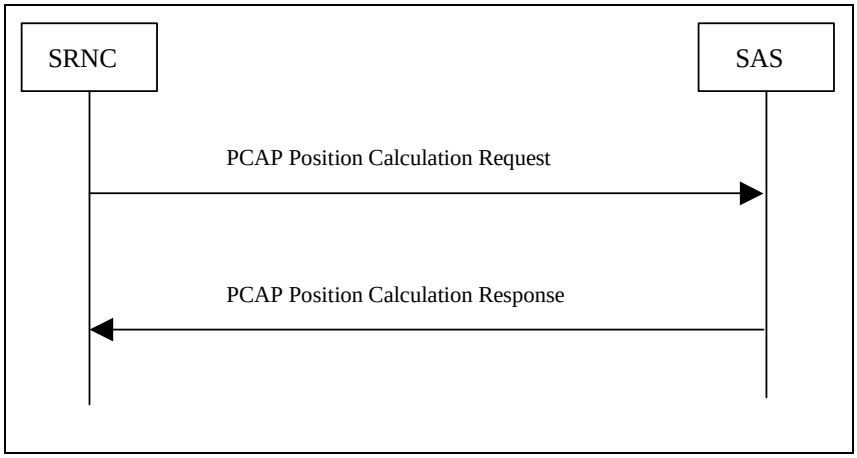

Figure 6.6: PCAP Position Calculation Message Flow

1. The SRNC initiates a PCAP Position Calculation Request Message. This message contains data necessary for the SAS to calculate a position estimate for a UE and, if required, initiate U-TDOA positioning for the UE.
2. If the SAS is able to calculate the position estimate, possibly after performing U-TDOA positioning if requested in step 1, it shall return it to the SRNC in a PCAP Position Calculation Response Message. If the SAS cannot fulfil the request, it shall return a PCAP Position Calculation Failure Message to the SRNC.

6.6.5.1.2 PCAP Information Exchange

The PCAP Information Exchange message flow illustrates how an RNC initiates and terminates an exchange of UE Positioning related information with an SAS. The UE Positioning related information received from the SAS can be used by the RNC to either provide assistance data to a particular UE through dedicated signalling or to build up System Information Blocks containing assistance data to be broadcast to UEs in a particular area.

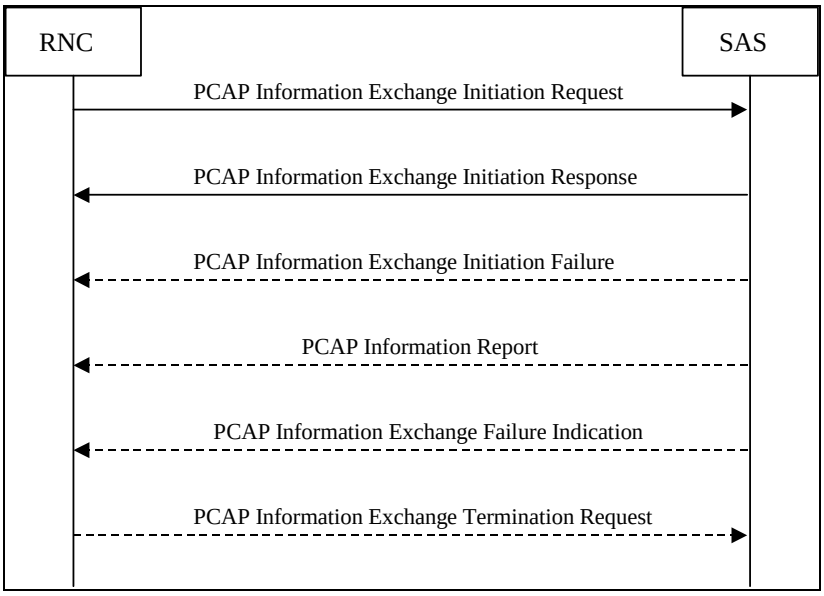

Figure 6.7: PCAP Information Exchange Message Flow

1. The RNC initiates a PCAP Information Exchange Initiation Request Message. This message contains data necessary for the SAS to provide the requested UE Positioning related information to the RNC. Upon reception of this message, the SAS shall provide the requested UE Positioning related information according to the reporting parameters given in the request. These parameters specify how the UE Positioning related information is to be reported (i.e. on-demand, periodically, or on-modification).

2. If the SASis able to determine the information requested by the RNC, it shall respond with a PCAP Information Exchange Initiation Response Message.

3. If the SAS cannot provide the requested UE Positioning related information, it shall return a PCAP Information Exchange Initiation Failure Message.

4. In cases where the RNC has specified that the UE Positioning related information is to be reported periodically or on-modification, the SAS shall return the requested information in one or more PCAP Information Report Messages.

5. In cases where the RNC has specified that the UE Positioning related information is to be reported periodically or on-modification, the SAS may initiate an Information Exchange Failure Indication Message to notify the RNC that the requested information associated with a particular reporting activity can no longer be reported.

6. In cases where the RNC has specified that the UE Positioning related information is to be reported periodically or on-modification, the RNC may terminate a particular information reporting activity by initiating a PCAP Information Exchange Termination Request Message. Upon reception, the SAS shall terminate the particular information exchange activity indicated by the RNC.

6.6.5.1.3 PCAP for SAS based Positioning Method Selection

As a configuration option, the SAS shall be able to determine the positioning method used for individual positioning events. In this case the SRNC shall allow A-GPS, OTDOA, Cell ID and U-TDOA positioning events to be originated by the SAS via PCAP messages on the Iupc interface.

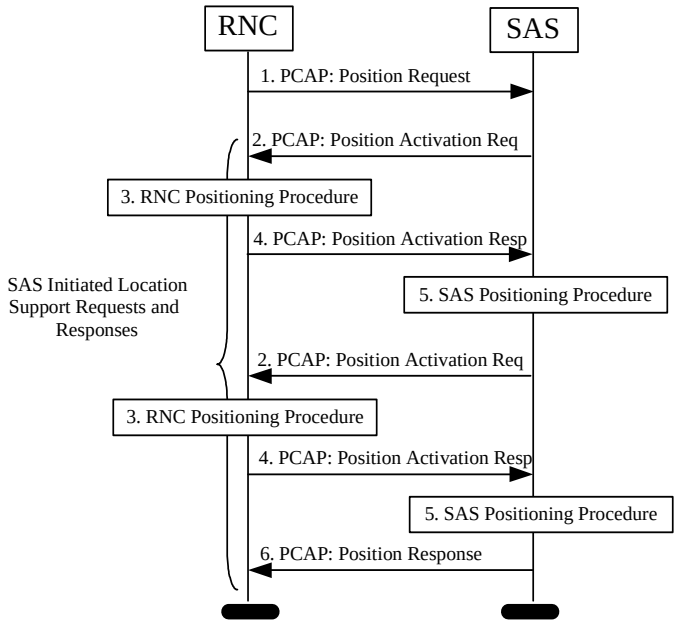

Figure 6.8: Fundamental SAS centric signal flow over the Iupc interface

1. The SRNC forwards the information contained in the RANAP Location Reporting Control message plus Cell ID and UE capability information to the SAS in a PCAP Position Request message.

2. The SAS may initiate a specific positioning method by sending a PCAP Position Activation Request message to the SRNC containing the required positioning method and any assistance data and instructions associated with that positioning method.

3. The SRNC performs the positioning procedure requested by the SAS including any signalling interaction with the UE in the case of UE assisted or UE based positioning (e.g. for A-GPS or OTDOA).

4. The SRNC sends a PCAP Position Activation Response message to the SAS confirming the requested action and providing any information required by the requested positioning method; e.g. UE channel information for the U-TDOA positioning method or A-GPS measurements for UE assisted A-GPS.

5. The SAS instigates any further positioning associated with the posititioning method chosen in step 2 – e.g. obtains measurements from LMUs in the case of U-TDOA.

   Note:

   Repeating steps 2, 3, 4 and 5 to invoke additional positioning methods may provide higher location accuracy or successfully provide UE locations under difficult propagation circumstances, e.g. the hybrid positioning method. When steps 2, 3, 4 and 5 are repeated, the SAS shall not send a new PCAP Position Activation Request message until the SRNC has responded to a previous request or the SAS has timed out on a response. The SAS may, however, send a new PCAP Position Activation Request message in a repetition of step 2 while SAS positioning for a previous step 5 is ongoing. In this case, SAS positioning (e.g. for U-TDOA) could execute in parallel with SRNC positioning (e.g. for A-GPS or OTDOA) thereby reducing overall response time.

6. The SAS provides the UE location to the SRNC in a PCAP Position Response message.

[Next Changed Section]

7.3 Exception procedures

7.3.1 Procedures in the SRNC

The SRNC can work in either the RNC centric mode or in a SAS centric mode where the SAS has control over the positioning procedures.

7.3.1.1 RNC Centric Mode

When a positioning attempt fails due to failure of a position method itself (e.g. due to inaccurate or insufficient position measurements and related data) and the SRNC is unable to instigate another positioning attempt (e.g. due to a requirement on response time), the SRNC shall return a Location response over the Iu interface containing a less accurate position estimate if available, even if this position estimate is not within the accuracy requested from the CN. In this case, the Location response shall indicate that the position estimate does not satisfy the requested accuracy. If a less accurate estimate is not available, the SRNC shall return a Location response message containing no position estimate and indicating the cause of failure.

When a positioning attempt is interrupted by some other unrecoverable error event inside the SRNC, the SRNC shall immediately terminate the positioning attempt and return a Location Response message containing the reason for the positioning attempt cancellation.

In networks that include an SAS, the SRNC will receive a PCAP Position Calculation Response message on the Iupc interface and then return a Location response over the Iu interface containing the results that were provided over the Iupc interface (a less accurate position estimate, cause of failure indication, etc). This is described in Subclause 7.3.4.

If the uplink channel characteristics for the target UE change while a U-TDOA positioning is ongoing, the SRNC shall send a PCAP Position Calculation Reset message to the SAS containing the updated channel characteristics and cell information.

When a positioning attempt is interrupted by some other unrecoverable error event inside the SRNC, the SRNC may also abort any dialogue previously opened with an LMU for the purpose of instigating position measurements for the UE being located.

7.3.1.2 SAS Centric Mode

When the SRNC is unable to accept a PCAP Position Activation Request message due to congestion or any other failure, the PCAP Position Activation Failure message shall be sent to the SAS on the Iupc interface.

When the SRNC is unable to continue positioning activity associated with receipt of a preceding PCAP Position Activation Request message due to cell reselection that results in a different SRNC, loss of contact with the UE or any other reason, the PCAP Abort message shall be sent to the SAS on the Iupc interface.

After positioning has been initiated by the RNC, a PCAP Reset shall be sent containing updated channel characteristics (including cell information) whenever the RF channel parameters associated with the UE connection change due to cell reselection or handover within the same SRNC, modification of the channel capacity or any other reason within the control of a single RNC. The SRNC should keep the SAS updated on any change in serving cell status (e.g. using PCAP Reset) so that the SAS can provide correct assistance data to the UE if the SAS later invokes additional positioning methods.

If the SRNC receives a new PCAP Position Activation Request message before it has responded to a previous PCAP request for the same UE or while it is still performing activity for a previous request (e.g. in the case of U-TDOA in CELL_FACH state), the SRNC shall terminate all activity for the previous request, including sending any response to the SAS, and shall process the new request.

7.3.2 Procedures in a LMU

An LMU shall return an error indication to its CRNC when positioning measurements previously ordered by the RNC cannot be provided due to any error condition.

7.3.3 Procedures in the target UE

A target UE shall terminate any positioning procedure or the transfer of RRC positioning assistance data without sending any response to the SRNC if any UE Positioning RRC message is received from the SRNC that starts some other RRC management procedure. The new RRC procedure shall then be executed by the UE.

7.3.4 Procedures in the SAS

The SAS can work in either the RNC centric mode or in a SAS centric mode where the SAS has control over the positioning procedures.

7.3.4.1 RNC Centric Mode

In the RNC centric mode, ~~W~~when a UE positioning attempt fails (e.g. due to inaccurate or insufficient position measurements and related data), the SAS may return a PCAP Position Calculation Response message over the Iupc interface containing a less accurate position estimate. If a less accurate estimate is not available or will not meet the accuracy requirement, the SAS may instead return a PCAP Position Calculation Failure message containing no position estimate and indicating the cause of failure.

When a positioning attempt is interrupted by some other unrecoverable error event inside the SAS, the SAS shall immediately terminate the positioning attempt and return a PCAP Position Calculation Failure message containing the reason for the positioning attempt cancellation.

7.3.4.2 SAS Centric Mode

If the SAS invokes a positioning method by sending a PCAP Position Activation Request message to the SRNC, it may subsequently receive a PCAP Abort, PCAP Position Activation Failure or PCAP Reset message from the SRNC, while positioning in the SRNC is active, according to sub-clause 7.3.1.2.

If the SAS receives a PCAP abort message it shall immediately cease positioning attempts and return a PCAP Position Response message to the SRNC carrying either any location estimate already obtained or no location estimate and a cause of failure indication. If the SAS receives a PCAP Postion Activation Failure message, the SAS may either terminate positioning as for receipt of a PCAP Abort or continue the positioning attempt using the same or other positioning methods, e.g. if permitted by the QoS response time requirement. If the SAS receives a PCAP Reset message, the SAS shall take the received information into account in either performing ongoing positioning (e.g. reconfigure LMUs for U-TDOA) or invoking new positioning (e.g. use new serving cell to provide A-GPS timing assistance).

If the SAS is unable to accept or continue processing a PCAP Position Request from the SRNC due to capacity constraints or equipment failure, a PCAP Position Response message shall be sent to the SRNC on the Iupc interface carrying an appropriate cause of the failure indication.

7.4 Radio interface timing procedures

The Radio Interface Timing determination system consists of functions in LMUs in the SRNC, and in the SAS for networks that include an SAS. The system runs continuously offering cell timing information for UE Positioning.

7.4.1 LMU Functions

The Radio Interface Timing functionality in the CRNC associated LMU should be capable of performing the following functions:

- The LMU performs necessary radio interface measurements from signals transmitted by Node Bs;
- If the LMU contains a common reference clock, e.g. GPS TOW, it time stamps reception of Node B signals by performing measurements of UTRAN GPS timing of cell frames;
- If there is no reference clock available, the LMU may make SFN-SFN Observed Time Difference or measurements, i.e. measures the time difference between arrival of SFNs from neighbouring Node Bs and a reference Node B;

- The LMU may perform some processing of measurements, like averaging and filtering, using parameters delivered to it, or in their absence using default settings.

[Next Changed Section]

8 Cell ID based positioning method

The Cell ID based positioning method can work in either the RNC centric mode or in a SAS centric mode where the SAS has control over the positioning procedures.

In the RNC centric Cell ID based method, the SRNC determines the identification of the cell providing coverage for the target UE. This subclause outlines the procedures for this positioning method. Subclause 8.1 provides procedures for the determination of the cell ID depending on the operational status of the target UE. Subclause 8.3 provides a procedure for the mapping of the cell ID to a corresponding SAI to be returned to the LCS application in the CN. The general flow to determine the cell ID is shown in figure 8.1.

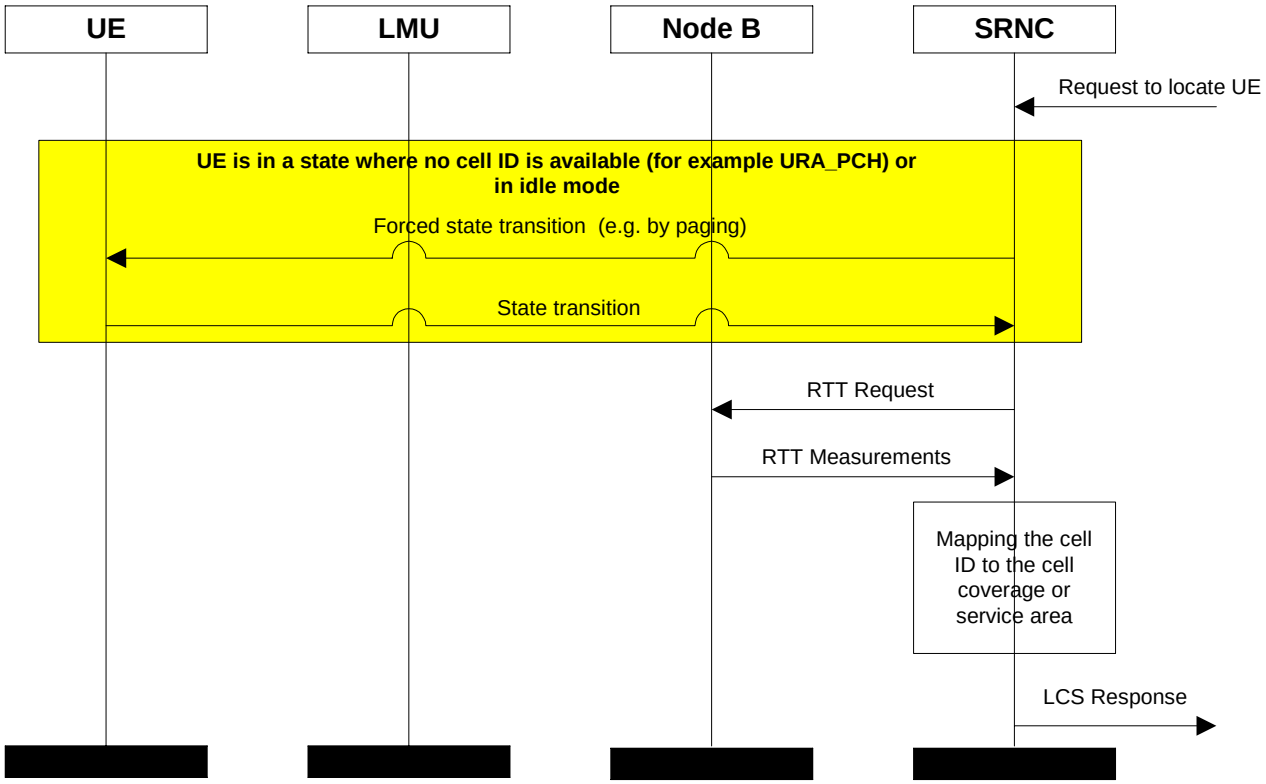

Figure 8.1: RNC Centric, Cell ID Based Method

In the SAS centric mode the request for a Cell ID based position may be originated by an associated SAS via a PCAP Postion Activation Request message on the Iupc interface as discussed in sub-clause 6.6.5.1.3. In this case the Cell ID and RTT measurements would be provided to the SAS in a PCAP Position Activation Response message as shown in figure 8.2.

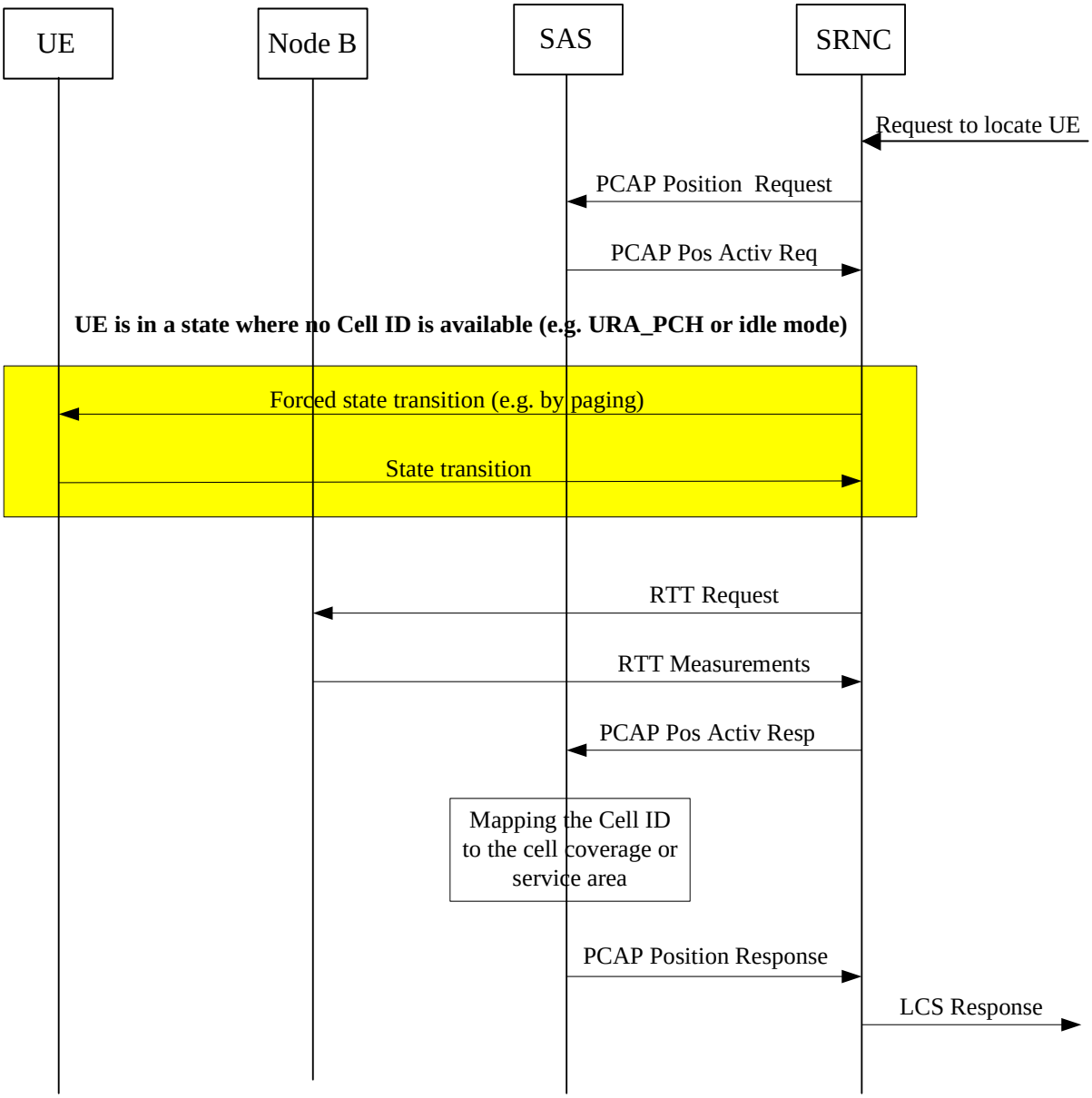

Figure 8.2: SAS Centric, Cell ID Based Method

8.1 Cell ID determination

In order for the SRNC to determine the cell ID when an UE Positioning request is received, additional operations may be needed depending on the operational status of the UE.

Figure 8.1 illustrates the procedure for the cell ID based positioning method when the UE is in different RRC states for the RNC centric mode. Figure 8.2 illustrates the procedure for Cell ID based positioning when the UE is in the different RRC states for the SAS centric mode. When the LCS request is received from the CN the SRNC checks the state of the target UE. If the UE is in a state where the cell ID is available, the target cell ID is chosen as the basis for the UE Positioning. In states where the cell ID is not available, the UE is paged, so that SRNC can establish the cell with which the target UE is associated. In order to improve the accuracy of the LCS response the SRNC may also request RTT (FDD only) or RX Timing Deviation (TDD only) or Angle of Arrival (1.28 Mcps TDD only) measurements from the Node B or LMU associated with the cell ID. The SRNC may also map the cell ID to a corresponding SAI to match the service coverage information available in the CN. In the case of 1.28 Mcps TDD, in order to improve the accuracy of the LCS response, the SRNC may request that the UE reports the internal measured result 'timing advance'. This step is not illustrated in figures 8.1 or 8.2.

The cell ID based method shall determine the position of the UE regardless of the UE RRC mode (i.e. connected or idle).

[Next Changed Section]

9.6 OTDOA network positioning procedures

OTDOA may be selected by the SRNC as the method to be used on receipt of a LCS positioning request from the CN or, optionally, when the SRNC receives a PCAP Position Activation Request message indicating the OTDOA positioning method from a SAS that is configured to select the positioning method. In the SAS initiated case the OTDOA measurement information will be returned to the SAS in a PCAP Position Activation Response message as discussed below.

9.6.1 RNC based selection of OTDOA

The following diagram illustrates the operations for the OTDOA method for UE Positioning when the request for positioning information is initiated by an LCS application from the CN.

This illustration only includes the information flow related to UE Positioning operations and does not indicate other operations that may be required, for example, to establish a signalling connection between the UE and the SRNC. Also not illustrated is the signalling used to initiate the location service request from the CN or a UE-based application.

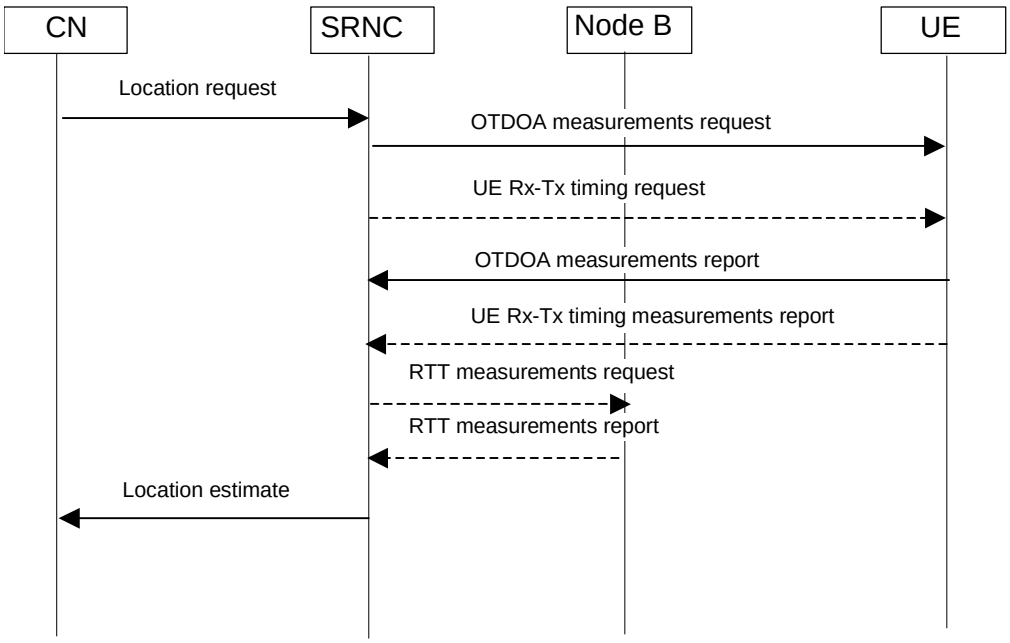

Figure 9.2: OTDOA Signalling Operations

1. The operation begins with an authenticated request for positioning information about a UE from an application in the CN being received at the SRNC. The SRNC considers the request and the UTRAN and UE capabilities.
2. The SRNC requests from the UE the measurement of the OTDOA for the signals in the active and neighbourhood sets. These measurements are made while the UE is in connected mode CELL_DCH state.
3. If it is considered advantageous to do so, the SRNC requests the UE Rx-Tx timing difference (FDD only) or UE timing advance, $T_{ADV,}$ (1.28 Mcps TDD) information from the UE.
4. The UE returns the OTDOA measures to the SRNC. The SRNC receives the OTDOA information and co-ordinates obtaining other information to support the calculation request.

5. The UE returns the UE Rx-Tx timing difference (FDD only) or UE timing advance, $T_{ADV,}$ (1.28 Mcps TDD) information to the SRNC, together with a time stamp of when the value was obtained.

6. If there are insufficient OTDOA measures, or it is otherwise considered advantageous to do so, the SRNC requests the RTT (in FDD) or Rx timing deviation (in TDD) and/or angle of arrival (in 1.28 Mcps TDD) measure for the UE from the serving Node B.

7. In FDD, the SRNC requests the RTD values for the associated transmitters from the associated database. These may be stored locally if they are constant over time, otherwise they must be updated to represent the RTD timing at the time-of-day the OTDOA measurements were made.

8. The Node B returns the RTT (in FDD) or Rx Timing Deviation (in TDD) and/or angle of arrival (in 1.28 Mcps TDD) measures to the SRNC if they were requested.

9. The SRNC performs a position calculation using the OTDOA, RTD and, if necessary, RTT (in FDD) or Rx timing deviation and UE timing advance (in TDD) information and angle of arrival information (1.28 Mcps TDD). The calculation may include a co-ordinate transformation to the geographic system requested by the application. The position estimate includes the position and the estimated accuracy of the results. In networks that include the SAS, the SAS may perform the position calculation and then pass the position estimate to the SRNC.

10. The SRNC passes the position estimate to the CN including, if available, the positioning method (or the list of the methods) used to obtain the position estimate. If the CN has requested an accuracy for the position estimate, the Location response shall include an indication whether the position estimate satisfies the requested accuracy or not.

9.6.2 SAS based selection of OTDOA

The following describes the signalling for the optional selection of the OTDOA positioning procedure by the SAS when the CN has requested UE positioning.

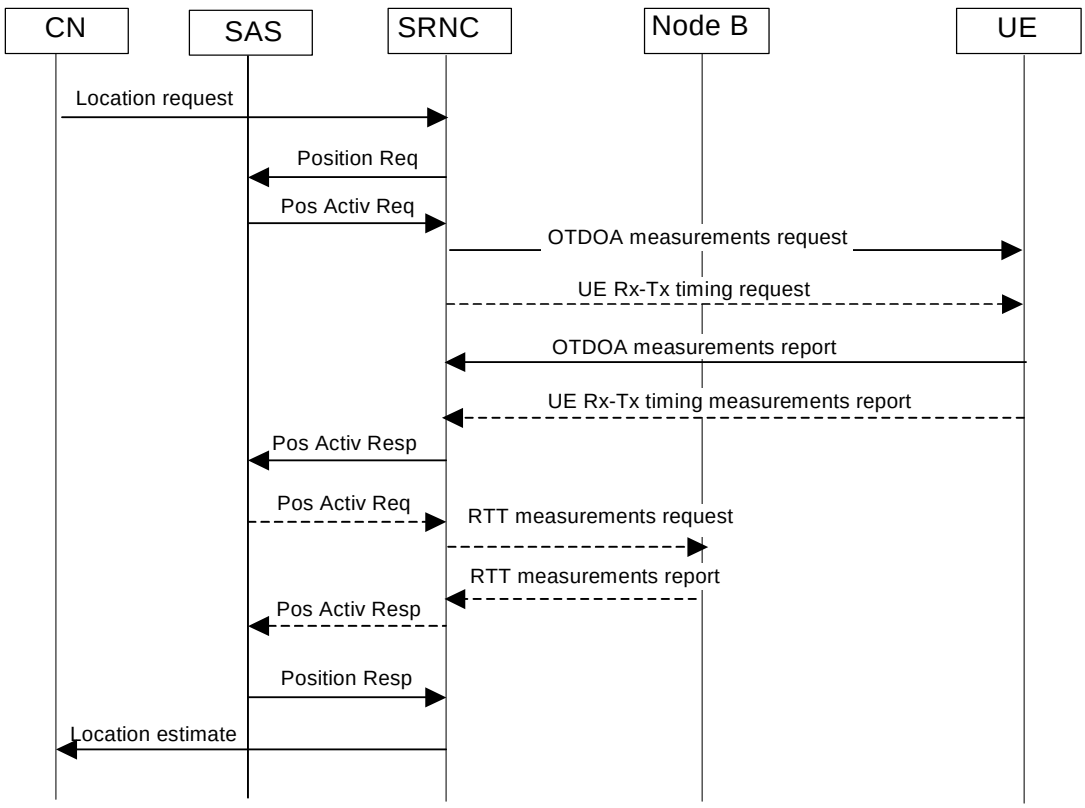

Figure 9.3: OTDOA Signalling Operations for SAS based positioning method selection

1. The operation begins with an authenticated request for positioning information about a UE from an application in the CN being received at the SRNC. The SRNC considers the request and the UTRAN and UE capabilities.

2. The SRNC forwards the information contained in the RANAP Location Reporting Control message plus the Cell ID and UE capability information to the SAS in a PCAP Position Request message.

3. The SAS sends a PCAP Position Activation Request message to the SRNC that requests the OTDOA positioning method and may also request the UE Rx-Tx timing difference (FDD only) or UE timing advance, $T_{ADV,}$ (1.28 Mcps TDD) information from the UE.

4. The SRNC requests from the UE the measurement of the OTDOA for the signals in the active and neighbourhood sets. These measurements are made while the UE is in connected mode CELL_DCH state.

5. If the SAS has requested Rx-Tx timing information, the SRNC requests the UE Rx-Tx timing difference (FDD only) or UE timing advance, $T_{ADV,}$ (1.28 Mcps TDD) information from the UE.

6. The UE returns the OTDOA measures to the SRNC. The SRNC receives the OTDOA information and co-ordinates obtaining other information to support the calculation request.

7. The UE returns the UE Rx-Tx timing difference (FDD only) or UE timing advance, $T_{ADV,}$ (1.28 Mcps TDD) information to the SRNC, together with a time stamp of when the value was obtained.

8. The SRNC forward the OTDOA measurement report information and, if available, the UE Rx-Tx timing measurement report information to the SAS in a PCAP Position Activation Response message

9. If there are insufficient OTDOA measures, or it is otherwise considered advantageous to do so, the SAS requests the RTT (in FDD) or Rx timing deviation (in TDD) and/or angle of arrival (in 1.28 Mcps TDD) measure for the UE from the serving Node B by sending a PCAP Position Activation Request message that requires the SRNC to execute the Cell ID positioning method toward the UE being positioned.

10. In FDD, the RTD values for the associated transmitters are calculated and stored in the SAS based upon input from its associated LMUs.

11. The Node B returns the RTT (in FDD) or Rx Timing Deviation (in TDD) and/or angle of arrival (in 1.28 Mcps TDD) measures to the SRNC if they were requested.

12. The SRNC forwards Cell ID and RTT (in FDD) or Rx timing deviation and UE timing advance (in TDD) information and angle of arrival information (1.28 Mcps TDD) to the SAS in a PCAP: Position Activation Response message.

13. The SAS performs the OTDOA based or Cell ID based position calculation and forwards the position information to the SRNC in a PCAP: Position Response message. The calculation may include a co-ordinate transformation to the geographic system requested by the application. The position estimate includes the position and the estimated accuracy of the results.

14. The SRNC passes the position estimate to the CN including, if available, the positioning method (or the list of the methods) used to obtain the position estimate. If the CN has requested accuracy for the position estimate, the Location response shall include an indication whether the position estimate satisfies the requested accuracy or not.

[Next Changed Section]

10.6 RNC based Network Assisted GPS positioning Procedure

The diagram in Figure 10.3 and Figure 10.2 illustrate the operations for the network assisted GPS when the request for position information is initiated by a LCS application signalled from the Core Network. A detailed description of the positioning procedure is given as follows. Note that the procedure is for illustration purpose and actual implementations may vary.

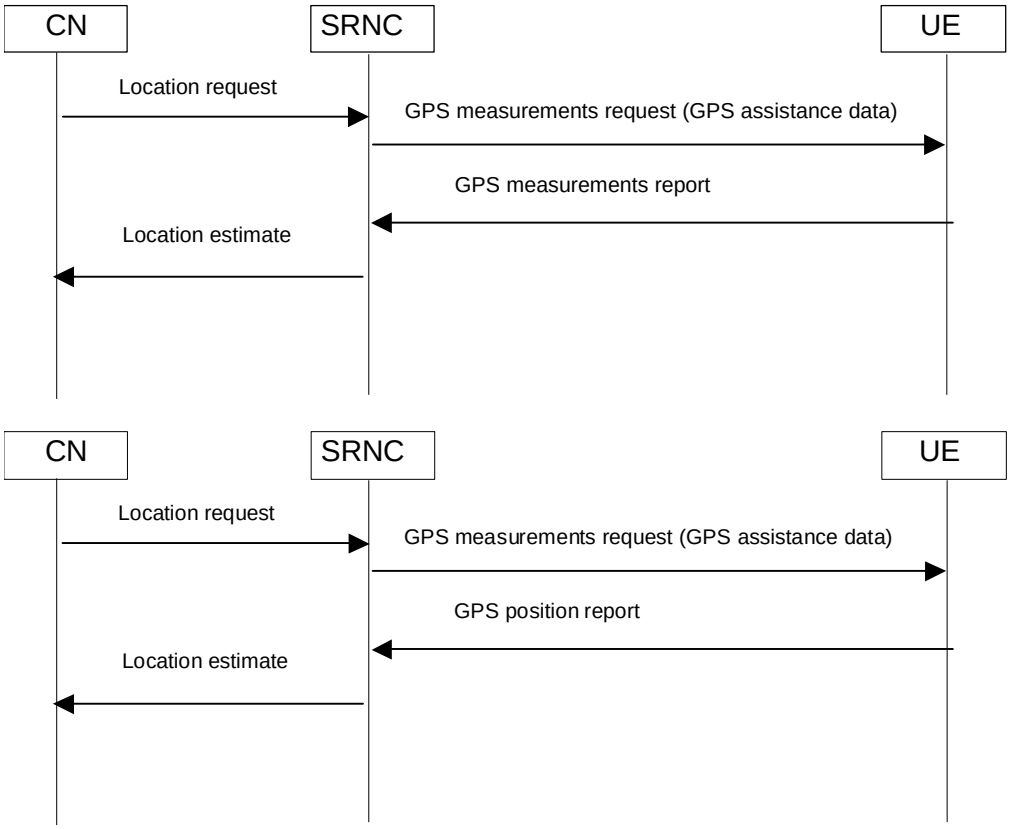

Figure 10.3: RNC based Network-assisted GPS methods

1. The operation begins with an authenticated request for positioning information about a UE from an application in the core network being received at the SRNC. The SRNC acts as interface between the Core Network and the UE Positioning entities in the UTRAN. The SRNC considers the request and the capabilities of the UE and the UTRAN. In networks that include the SAS, the SRNC may invoke the SAS via the Iupc interface.

2. Depending on the UE capabilities, the network sends to the UE certain GPS assistance information. This information may include: the reference time for GPS, the satellite IDs, the Doppler frequency, the search window and its centre, the ephemeris and clock corrections, the almanac, and other information specified in 10.5.1. If the UE has not enough assistance data to perform the measurements, the UE should indicate it to the SRNC and additionally request for assistance data.

   For UE-based method, jump to step 8.

   For UE-assisted method, the SRNC may optionally request the following information before the assistance message(s) is (are) sent to the UE: the LMU update (see NOTE), the RTT measurements (from the Node Bs in the active set) to compensate for the one-way propagation delays. The LMU (associated or stand-alone) returns the information containing the time difference between the Node B and the GPS (e.g. UTRAN GPS timing of cell frames or SFN-SFN Observed Time Difference) to the CRNC. The Node B returns its RTT measurement to the CRNC. If the CRNC is not the SRNC, the CRNC forwards these information to SRNC.

4. The network requests from the UE the measurement of GPS satellite pseudoranges and other information specified in 10.5.1. These measurements may be made while the UE is in RRC connected mode CELL_DCH state. The SRNC may request SFN-SFN Observed Time Difference measurements and Rx-Tx timing difference information from the UE to support the processing related to the RTT measurements.

5. The UE returns to the network the measurement of GPS satellite pseudoranges and other information specified in 10.5.1. If requested, the UE returns to the SRNC SFN-SFN measurements and the Rx-Tx time difference information, together with a time stamp of when these values were obtained.

6 The UE position is calculated in the network.

7. If there is insufficient information to yield a UE positioning estimate, the SRNC may start a new process from step 3.

8. In case of UE based method, UE returns the position estimate to the SRNC. This estimate includes the position, the estimated accuracy of the results and the time of the estimate.

9. In networks that include the SAS, the SAS passes the position estimate to the SRNC.

10. The SRNC passes the position estimate to the CN including, if available, the positioning method (or the list of the methods) used to obtain the position estimate. If the CN has requested an accuracy for the position estimate, the Location response shall include an indication whether the position estimate satisfies the requested accuracy or not.

NOTE: The LMU update (of the time difference between the GPS and the Node B) may be performed on a per-request basis (with respect to each UE Positioning request) or be performed timely that is independent of individual UE Positioning request. The latter is preferable when there is a large volume of UE Positioning requests.

10.7 SAS initiated Network Assisted GPS positioning Procedure

The following describes the signalling for the optional initiation of the network assisted GPS positioning procedure by the SAS.

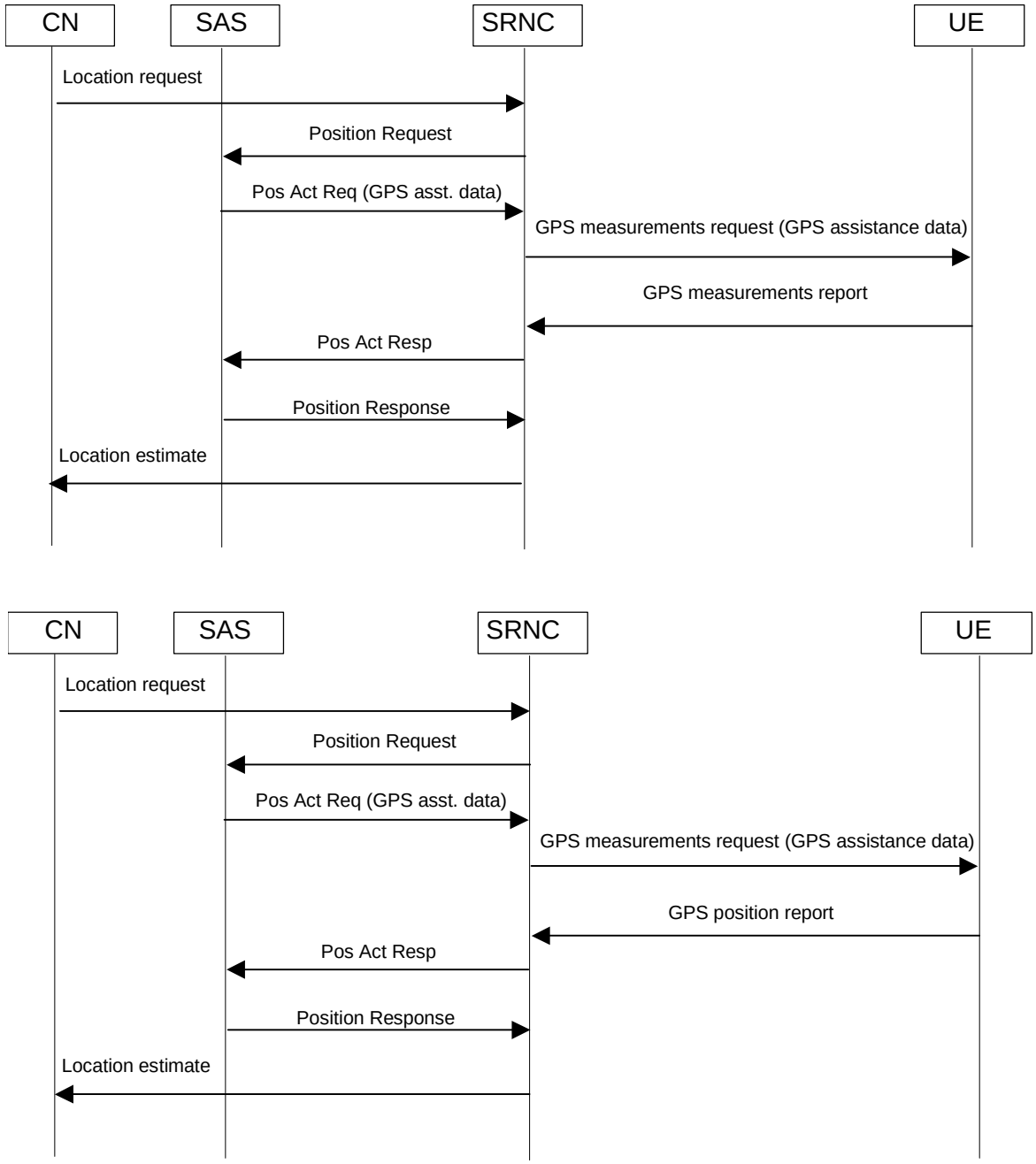

Figure 10.4: Network-assisted GPS methods when initiated by the SAS

1. The operation begins with an authenticated request for positioning information about a UE from an application in the core network being received at the SRNC. The SRNC acts as interface between the Core Network and the UE Positioning entities in the UTRAN.

2. The SRNC sends parameters received in the location request together with the Cell ID and UE capability information to the SAS in a PCAP: Position Request message via the Iupc interface.

3. Depending on the UE capabilities, the SAS initiates an A-GPS positioning procedure by sending a PCAP: Position Activation Request message containing A-GPS assistance data to the SRNC via the Iupc interface. The SAS may provide all or some A-GPS assistance data needed by the UE. This may include timing assistance data that the SAS may have obtained from associated LMUs or from another source (e.g. GPS Reference Network or measurements from UEs previously positioned by the SAS using A-GPS).

4. The SRNC forwards to the UE the A-GPS positioning request received from the SAS using RRC signalling. The SRNC also forwards in the RRC signalling message(s) the SAS request for either A-GPS measurements,

in the case of UE assisted A-GPS, or an A-GPS position estimate, in the case of UE based A-GPS. For a description of UE based A-GPS, jump to step 9.

5. For UE assisted A-GPS, the SRNC requests from the UE the measurement of GPS satellite pseudoranges and other information specified in 10.5.1. These measurements may be made while the UE is in RRC connected mode CELL_DCH state. The SRNC may request SFN-SFN Observed Time Difference measurements and Rx-Tx timing difference information from the UE to support the processing related to the RTT measurements.

6. The UE returns to the SRNC the measurement of GPS satellite pseudoranges and other information specified in 10.5.1. If requested, the UE returns to the SRNC SFN-SFN measurements and the Rx-Tx time difference information, together with a time stamp of when these values were obtained.

7. The information obtained in step 6 is sent from the SRNC to the SAS in a PCAP: Position Activation Response message.

8. The SAS calculates the UE position and returns it to the SRNC in a PCAP: Position Response message together with the positioning method(s) used and an indication of whether the position estimate satisfies the requested accuracy or not.

9. In case of UE based method, the UE returns the position estimate to the SRNC via RRC signalling. The SRNC forwards the position estimate to the SAS in a PCAP: Position Activation Response message. This estimate includes the position, the estimated accuracy of the results and the time of the estimate.

10. The SAS may verify the UE position estimate received in step 9 (e.g. using cell ID information) and returns the resulting estimate to the SRNC in a PCAP: Position Response message together with the positioning method(s) used and an indication of whether the position estimate satisfies the requested accuracy or not.

11. If there is insufficient information to yield a UE positioning estimate satisfying the requested accuracy, the SAS may start a new process from step 3.

12. The SRNC passes the position estimate received from the SAS to the CN including the positioning method (or the list of the methods) used to obtain the position estimate. If the CN has requested accuracy for the position estimate, the Location response shall include an indication whether the position estimate satisfies the requested accuracy or not.

NOTE: An update to the SAS from an associated LMU, of the time difference between GPS and the Node B, may be performed on a per-request basis (with respect to each UE Positioning request) or be performed in a timely manner that is independent of individual UE Positioning requests. The latter is preferable when there is a large volume of UE Positioning requests.

[Next Changed Section]

12 Uplink-Time Difference Of Arrival (U-TDOA) positioning method

12.1 General

The U-TDOA method calculates the location of a transmitting UE by using the difference in time of arrival of signals at different LMUs. The time required for a signal transmitted by a UE to reach a U-TDOA capable LMU is proportional to the length of the transmission path between the UE and the U-TDOA capable LMU. The U-TDOA method does not require knowledge of the time the UE transmits nor does it require any new functionality in the UE.

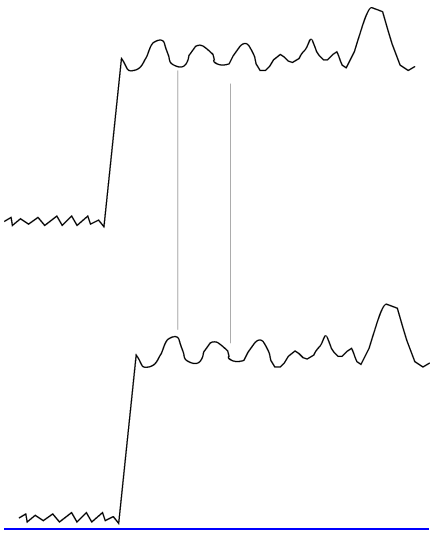

Figure 12.1: Ideal Signal Collection

Figure 12.1 shows a time domain representations of two perfectly matched signals as received from the same UE by two U-TDOA capable LMUs in ideal conditions, including high signal-to-noise ratio and no multipath distortion. Because the receivers are at different distances from the transmitting UE, the signals are out of phase; they do not correlate.

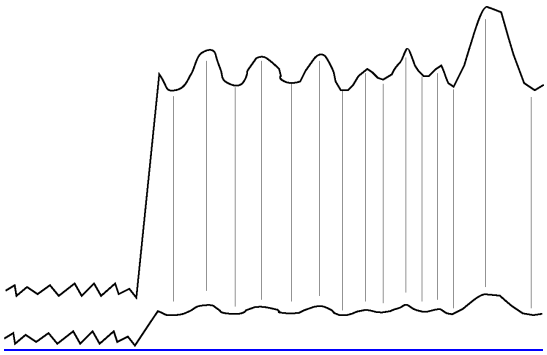

Figure 12.2. Ideal and Attenuated Waveforms

Figure 12.2 shows the theoretical effects of increased distance, multipath distortion, and interference on a received signal. The top signal was received under ideal conditions. The lower one represents what that signal would look like in more realistic conditions. It is attenuated to a level much closer to the noise floor. Nevertheless, there is a correlation with the original signal.

Cross-correlation is a statistical technique that compares the waveforms of two signals point for point. Identical signals in perfect phase would yield a correlation coefficient of 1. In Figure 12.3, even though the waveform in (b) is attenuated compared to (a), the alignment would still yield a very high correlation, say 0.999.

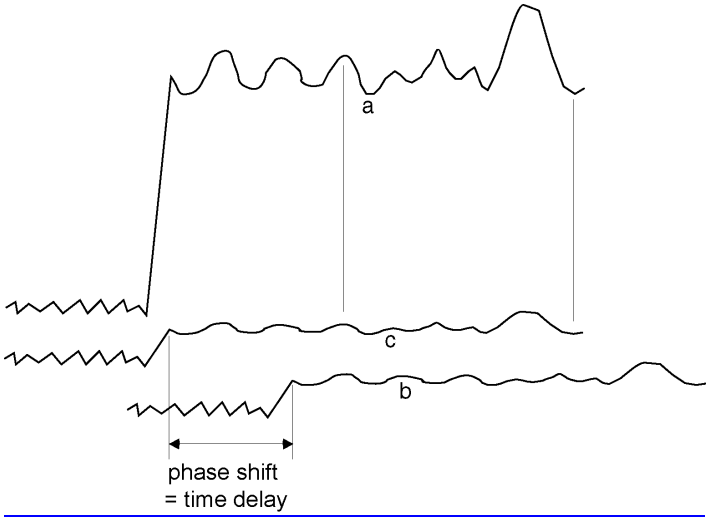

Figure 12.3. Using Cross-Correlation to Compute Time Delay

Figure 12.3 shows (a) a signal received by a U-TDOA capable LMU that is close to the transmitter and (b) the same signal received by a second U-TDOA capable LMU farther away. The latter signal is attenuated and perhaps distorted. It is also out of phase with the original signal because it was received at a later time. The correlation coefficient between (b) and (a) would be quite low. However, by shifting the (b) curve to the left, it is possible to find a position in which the correlation coefficient is maximized (shown by (c)). For this position, the amount of shift required is equal to the arrival time difference of the signal between the two U-TDOA capable LMUs.

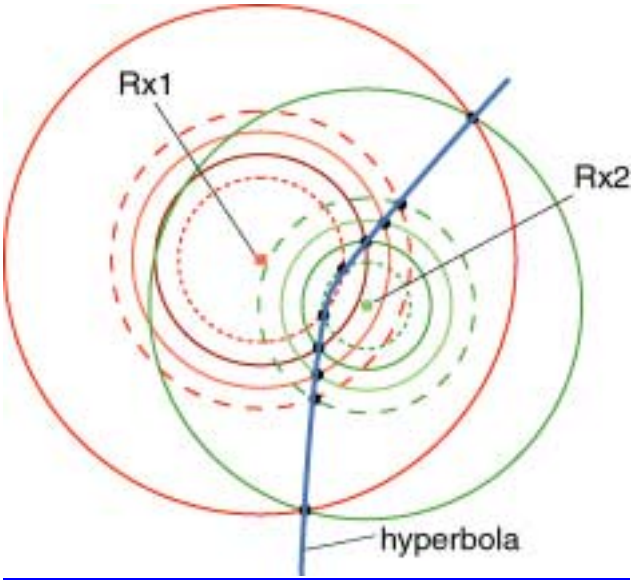

Figure 12.4. Deriving the Hyperbolic Function for Time Delay

In this model (Figure 12.4), Rx1 and Rx2 represent fixed locations of two U-TDOA capable LMUs in a network. The pairs of intersecting circles centered around Rx1 and Rx2 have radii such that each radius represents the time, t_{TR}, it takes a signal to travel from a UE transmitter to each U-TDOA capable LMU (that time being unknown). The difference between radii is a constant equal to the difference between t_{TR1} for the first U-TDOA capable LMU and t_{TR2} for the second U-TDOA capable LMU. $t_{TR1} - t_{TR2}$ is the value that the U-TDOA system measures. When you plot and connect the points of intersections between each pair of circles, the resulting shape is a hyperbola. The hyperbola defined by the reference site in comparison to another site constitutes a baseline. If you constructed a similar hyperbola for another pair of U-TDOA capable LMUs receiving transmissions from the same UE, that hyperbola would intersect

at two points with the first hyperbola, yielding two possible locations for the UE. A third such hyperbola (Figure 12.5) would yield a unique location for the calling phone, so that a minimum of four reception sites is needed to obtain the unique location estimate.

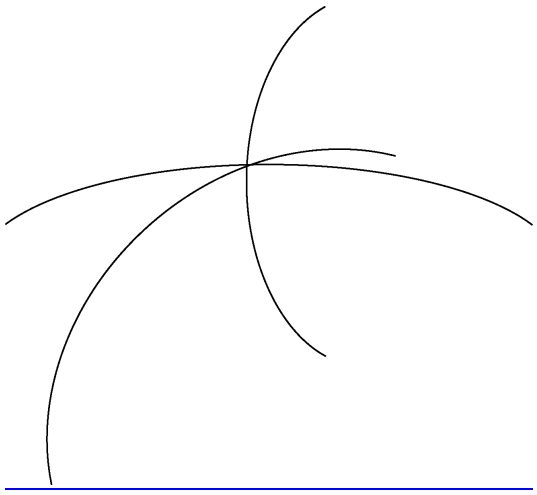

Figure 12.5. Intersection of Three Hypothetical Hyperbolas Calculated from Time Delay Differences

In the U-TDOA method, the reference measurement is the one that represents the U-TDOA capable LMU site that collects the signal with the highest quality. That site is usually the site closest to the UE, and normally generates the highest signal level as well as the highest SNR. In addition, it presumably exhibits the lowest multi-path error. Therefore the reference time delay is the one against which time differences are measured. Any errors introduced into the time delay measurement yield inaccuracies in the intersection point. Since the speed of light is approximately 0.3 m/nsec in air, a nanosecond error in time delay measurement introduces 0.3 meters of error.

The more hyperbolas that are calculated, that is, the more cooperating U-TDOA capable LMUs used in the calculation, the more accurate is the estimate of the UE's position. This is another way of saying that statistical confidence improves with an increase in sample points. When many sites enter into the calculation, the effects of a large time delay measurement error at a single site are minimized.

12.2 U-TDOA SAS architecture

The overall network architecture is simlar to the previous architecture and is illustrated in Figure 12.6. The only difference is that the U-TDOA capable LMU are connected directly to the SAS via an overlay network.

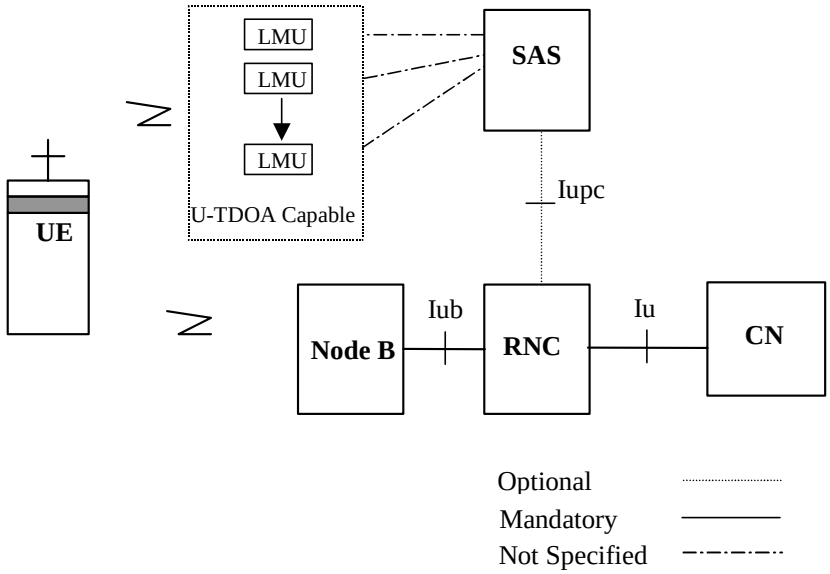

Figure 12.6 – U-TDOA SAS Architecture

The impact on the SAS centric approach due to the presence of the Iur is FFS.

12.3 RNC based U-TDOA positioning for Cell_DCH and Cell_FACH RRC states

The U-TDOA positioning method can be performed when the UE is in either the CELL_DCH or CELL_FACH RRC states. If the UE is in the CELL_PCH or URA_PCH state the SRNC shall first bring the UE to the CELL_FACH or CELL_DCH states so that the U-TDOA measurements can be performed by the LMUs and to provide the current serving Cell ID if the UE was in the URA_PCH state.

12.3.1 UE in CELL_DCH state

The SRNC may invoke the U-TDOA positioning method using the PCAP: Position Calculation Request message that contains the Cell ID and RF channel information for the UE being positioned when that UE is in the CELL_DCH state. The SAS executes the U-TDOA positioning method and returns the location or appropriate error indication to the SRNC using the PCAP: Position Calculation Response message as described below.

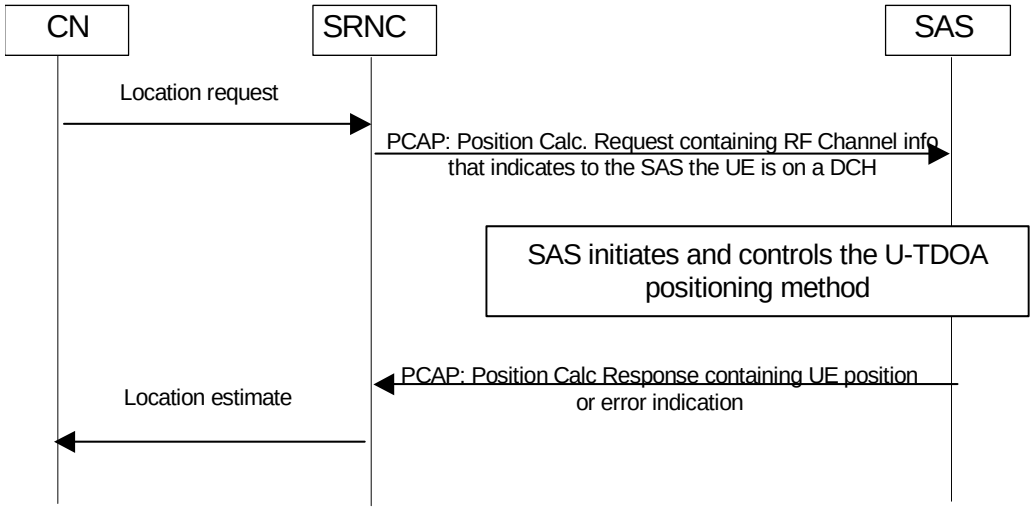

Figure 12.7: RNC initiated U-TDOA positioning procedure in CELL_DCH state

1. The operation begins with an authenticated request for positioning information about a UE from an application in the core network being received at the SRNC in a RANAP: Location Reporting Conrol message. The SRNC may invoke the U-TDOA positioning method via the Iupc interface.

2. The SRNC sends a PCAP: Position Calculation Request message to the SAS containing the contents of the RANAP Location Reporting Control message, the RF channel information and Cell ID for the UE being positioned. This information indicates that the UE is in the CELL_DCH state.

3. The SAS configures the U-TDOA capable LMUs, analyzes the returned information and calculates the UE position.

4. The SAS returns the UE position or error indication to the SRNC in a PCAP: Position Calculation Response message.

5. The SRNC returns the UE position to the CN in a RANAP: Location Report message.

12.3.2. UE in CELL_FACH state

The SRNC may invoke the U-TDOA positioning method using the PCAP: Position Calculation Request message that contains the contents of the RANAP Location Reporting Control message, Cell ID and RF channel information for the UE being positioned. If the UE is in the CELL_FACH state the SRNC, after sending the Position Calculation Request message, shall execute a procedure that causes the UE being positioned to transmit a certain number of pre-coded bits within a certain period of time. The procedure described in steps 6-8 in sub-clause 12.4.2.1 below is offered as an example that could be used for the U-TDOA positioning method when the UE is in the CELL_FACH state.

The SAS executes the U-TDOA positioning method and returns the location or appropriate error indication to the SRNC using the PCAP: Position Calculation Response message as described below.

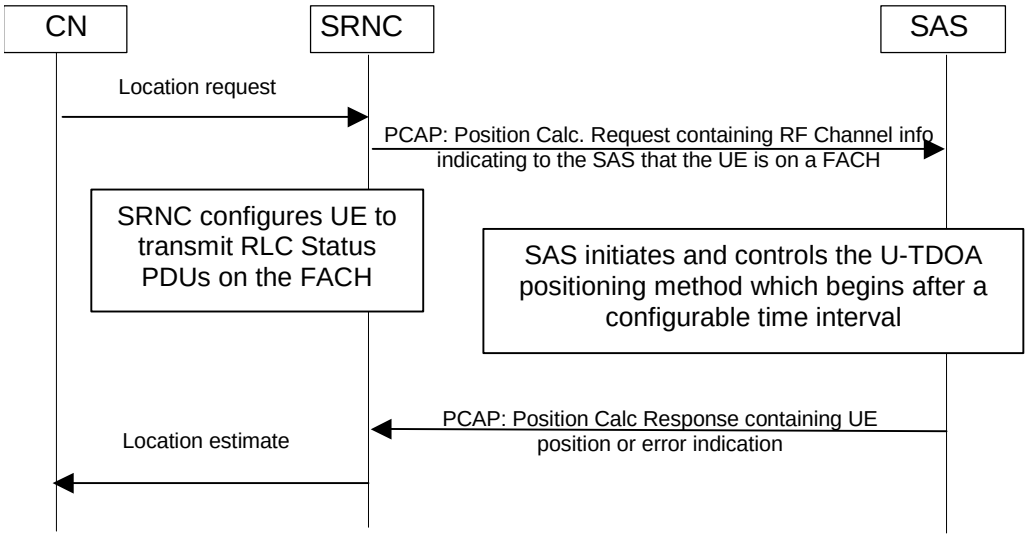

Figure 12.8: RNC initiated U-TDOA positioning procedure in CELL_FACH state

1. The operation begins with an authenticated request for positioning information about a UE from an application in the core network being received at the SRNC in a RANAP: Location Reporting Conrol message. The SRNC may invoke the U-TDOA positioning method via the Iupc interface.

2. The SRNC sends a PCAP: Position Calculation Request message to the SAS containing the contents of the RANAP Location Reporting Control message, the RF channel information and Cell ID for the UE being positioned. This information indicates that the UE is on a FACH.

3. After sending the Position Calculation Request message the SRNC shall execute a procedure that causes the UE being positioned to transmit a certain minimum number of pre-coded bits within a recommended maximum time interval of three seconds. The number of bits and actual time interval should be related to the required location accuracy, the propagation conditions in the serving cell and the LMU configuration for the SAS and may be determined in an implementation dependent manner. As an example of a method to cause the UE to transmit, the SRNC may configure the UE to transmit RLC Status PDUs as described in sub-clause 12.4.2 below.

4. After a configurable time interval the SAS configures the U-TDOA capable LMUs, analyzes the returned information and calculates the UE position.

5. The SAS returns the UE position to the SRNC in a PCAP: Position Calculation Response message.

6. The SRNC returns the UE position to the CN in a RANAP: Location Report message.

12.4 Optional SAS initiated U-TDOA positioning for Cell_DCH and Cell_FACH RRC states

This subclause describes the U-TDOA positioning procedures in the CELL_DCH and CELL_FACH states when the location method to be used is determined by the SAS.

12.4.1 UE in CELL_DCH state

Data (either signalling data (DCCH) or user data (DTCH)) transmitted by a UE in CELL_DCH state will always be sent on the DCH (Transport Channel). The DCH in turn is mapped to the DPDCH (Dedicated Physical Data Channel) by the MAC layer. The DPDCH is identified by the allocated frequency, the channelization code and the scrambling code.

The DPDCH always has an associated DPCCH (Dedicated Physical Control Channel). The DPCCH carries control information relevant to the physical layer. The DPCCH is under the same scrambling code, but uses a different spreading code.

While the DPDCH is active only during actual transmission of user data, the DPCCH is continuously transmitted as long as the UE is in the CELL_DCH state. The UE transmits either the DPCCH *and* the DPDCH, or solely the DPCCH – the scrambling code allocated to the UE can be received continuously as long as the UE is in the CELL_DCH state.

When the UE is in CELL_DCH state, the allocated scrambling code can be used to identify the UE for U-TDOA positioning determination. No additional interference is generated to locate the UE using the U-TDOA positioning method when in the CELL_DCH state.

12.4.1.1 Message Flow

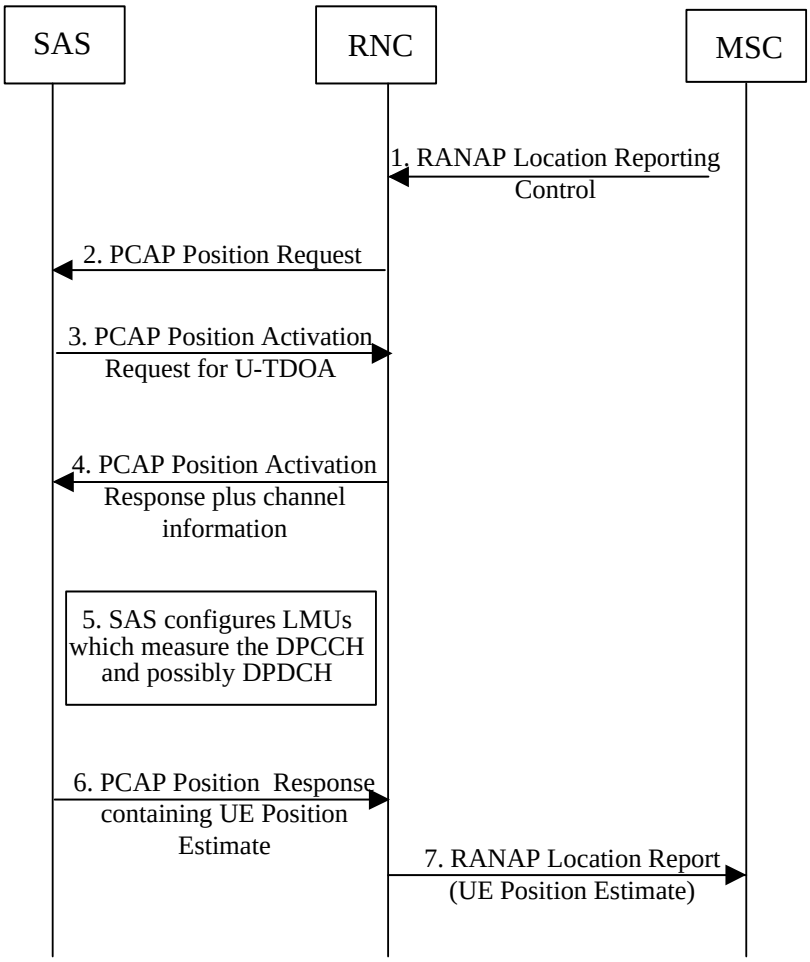

Figure 12.9 U-TDOA message flow, UE in the CELL_DCH state

1) The procedure starts when a RANAP: Location Reporting Control message requesting a geographical UE position is received at the SRNC.

2) Location Reporting Control message parameters plus UE capability information plus Cell ID are forwarded to the SAS in the PCAP: Position Request message.

3) Based upon the service type (emergency service, etc), and the requested QoS, the SAS initiates a U-TDOA position, and sends a PCAP: Position Activation Request message indicating U-TDOA to the SRNC. The SRNC chooses to bring the UE to the CELL_DCH state if not already in this state.

4) The SRNC returns U-TDOA channel information in a PCAP: Position Activation Response message to the SAS.

5) The SAS configures the U-TDOA capable LMUs to perform measurements. The U-TDOA capable LMUs measure the DPCCH and possibly DPDCH.

6) The SAS obtains a position estimate using the U-TDOA capable LMU measurements and returns it to the SRNC in a PCAP: Position Response message.

7) The SRNC returns the position estimate to the MSC in a RANAP: Location Report message.

12.4.2. UE in CELL_FACH state

In the CELL_FACH state the mobile is sharing a common uplink channel and is usually not sending data in the uplink direction. It is not possible to rely on the user application to cause the UE to transmit. For the U-TDOA location method the SRNC must force the UE to transmit.

As an example, this may be achieved by sending a RRC Radio Bearer Reconfiguration message that causes the UE to periodically send a RLC: Status PDU to the SRNC. When sufficient repetitions have occurred to meet the requested location QoS the RRC Radio Bearer Configuration message would be used to return the UE to the default state.

12.4.2.1 Message flow

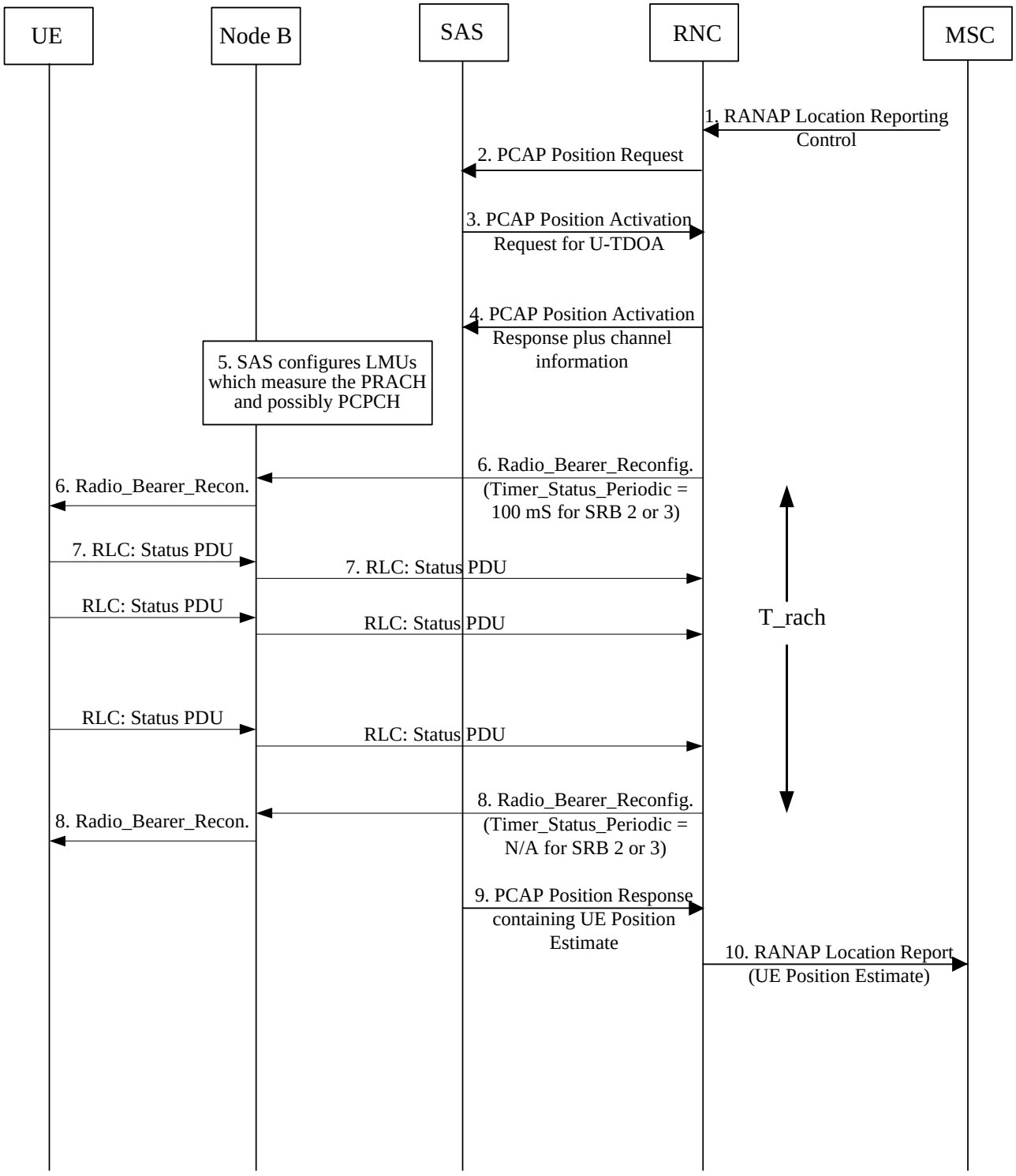

Figure 12.10 Example U-TDOA message flow, UE in the CELL_FACH state

1) The procedure starts when a RANAP: Location Reporting Control message requesting a geographical UE position is received at the SRNC.

2) Location Reporting Control message parameters plus Cell ID plus UE capability information are forwarded to the SAS in the PCAP: Position Request message.

3) Based upon the service type (emergency service, etc), and the requested QOS, the SAS initiates a U-TDOA position, and sends a PCAP: Position Activation Request message indicating U-TDOA to the SRNC. The SRNC chooses to bring the UE to the CELL_FACH state if initially in the CELL_PCH or URA_PCH state.

4) The SRNC returns U-TDOA channel information in a PCAP: Position Activation Response message to the SAS.

5) The SAS configures the U-TDOA capable LMUs to perform measurements. The U-TDOA capable LMUs measure the PRACH or PCPCH bursts associated with the UE being positioned.

6) The SRNC, after sending the PCAP Position Activation Response message, shall execute a procedure that causes the UE being positioned to transmit a certain number of pre-coded bits within a certain period of time. The number of pre-coded bits and period of time should be based upon (e.g. set equal to) a recommended number of bits and recommended time interval defined by the SAS in the PCAP Position Activation Request message invoking U-TDOA positioning. As an example, the SRNC could reconfigure the radio bearer so that the UE begins to send RLC status PDUs every 100 mS by sending the UE a Radio_Bearer_Reconfiguration message with the TimerStatusPeriodic IE configured for 100 milliseconds.

7) The UE begins to send RLC status PDUs every 100 milliseconds.

8) After expiration of the configurable T_rach timer the SRNC sends the UE a Radio_Bearer_Reconfiguration message with the TimerStatusPeriodic IE set to NA in order to stop the periodic status reporting.

9) The SAS obtains a position estimate using the U-TDOA capable LMU measurements and returns it to the SRNC in a PCAP: Position Response message.

10) The SRNC returns the position estimate to the MSC in a RANAP: Location Report message.

[Last Changed Section]

Annex B (informative): Reference Model of Functional Entities for UTRAN UE Positioning

The UTRAN functional entities for UE Positioning are shown in figure B.1 and figure B.2. In these reference models, the LCS clients in the core network communicate with the UTRAN UE Positioning entities across the Iu interface. The RNC LCS Handling Entities and the Positioning Handing Entities work together with the UE to measure and calculate the position information for the requested target UE. These entities within the UTRAN are described in more detail in the following subclauses.

The figure shows the general arrangement of the UE Positioning function in UTRAN. Communication among these entities makes use of the messaging and signalling capabilities of the UTRAN across the Iu, Iur, Iub, Iupc and Uu interfaces. A LMU is also added to the UTRAN to make measurements as needed by the selected positioning method.

This figure does not include elements of 3G Core Network, but focuses on those that participate with the UE Positioning functions in the UTRAN. The association of the LCS entities within the Core Network (CN) (e.g. with 3G-MSC or 3G-SGSN) is outside the scope of the present document and is not illustrated in the diagram.

Within the UTRAN, the UE Positioning Entities may be associated with, or part of the SAS, RNC, the Node B and the UE. Internal LCS Applications may also be part of the RNC and the UE.

The UE Position Calculation Function (PCF) is logically associated with the SRNC or with the SAS.

The UE Positioning in UTRAN also makes use of the standardised Iur interface between RNCs, when Node B information, measurements and results are collected.

The functional model presented in the figure includes functional entities for UE utilising either or both circuit switched (CS) and packet switched (PS) services. This model also supports of all the entities needed for different positioning methods (e.g. network-based, UE-based, UE-assisted, and network assisted (see note 1) methods) exploiting either uplink or downlink measurements.

NOTE 1: In this approach UE may use the GPS technique but still make use of auxiliary information from the serving network.

NOTE 2: Figure B.2 shows the SMLC as a node that implements the PCF. In actuality it is more than the PCF, for example, the SMLC can provide GPS assistance data. See Subclause 5.2.5 for the normative definition of an SMLC.

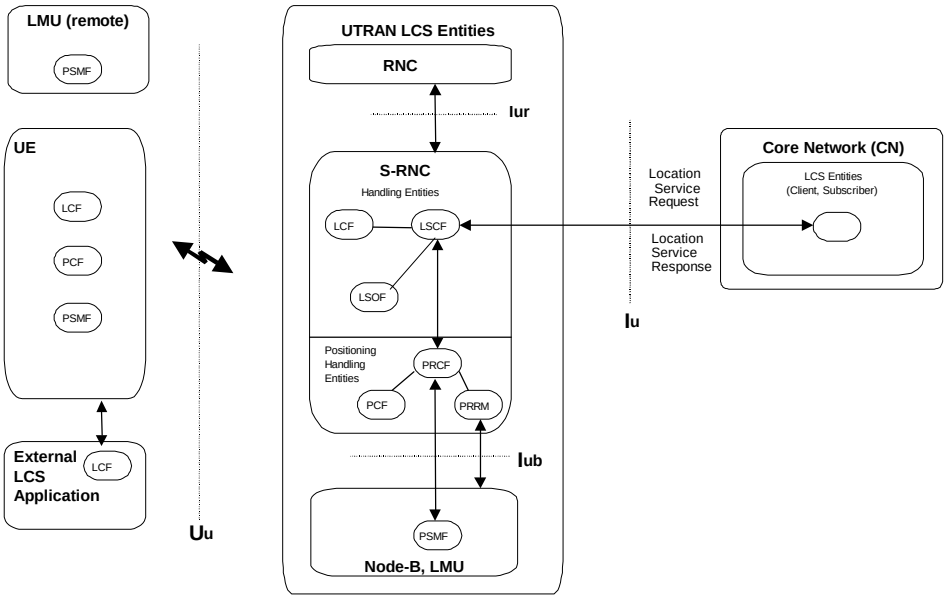

Figure B.1: UTRAN UE Positioning Functional Entities (RNC centric mode)

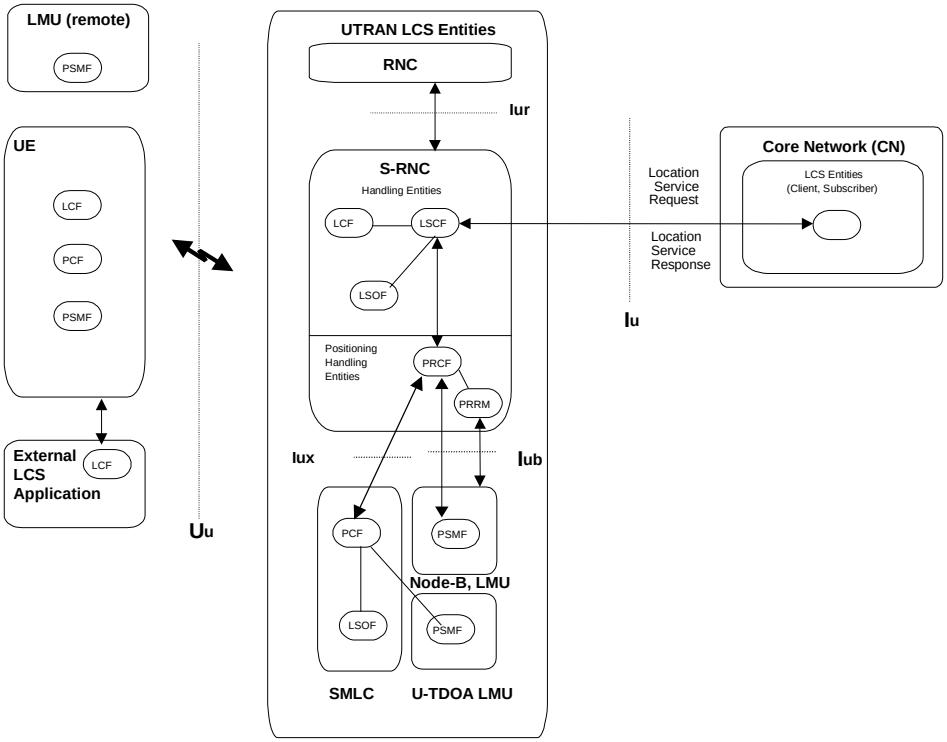

Figure B.2: UTRAN UE Positioning Functional Entities – SAS version (RNC centric mode)

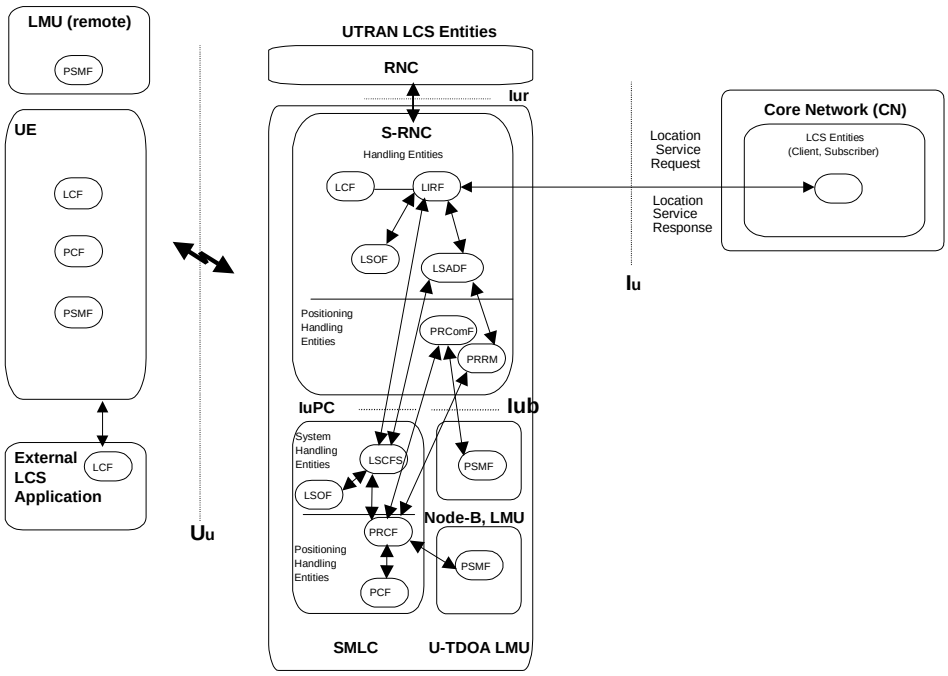

Figure B.3: UTRAN UE Positioning Functional Entities – SAS version (SAS centric mode)

Several functional groupings may be defined to describe the UE Positioning functions. These groupings occur in both the CN and the UTRAN. The overall LCS functional grouping is described in reference [13]. Each grouping encompasses a number of functional components and functions.

Within UTRAN the functional entities may be grouped as follows:

- the *Internal Client* group that includes:
  - Internal UTRAN Location Client Function (U-LCF);
- the *UTRAN System Handling* group that includes:

  For RNC centric mode:
  - UTRAN Location System Control Function (U-LSCF),
  - UTRAN Location System Operations Function (U-LSOF);

  For SAS centric mode:
  - UTRAN Location Information Relay Function (U-LIRF)
  - UTRAN Location System Control Function in SAS (U-LSCFS)
  - UTRAN Location System Assistance Data Function (U-LSADF)
- the *UTRAN Positioning* group that includes:
  - UTRAN Position Radio Co-ordination Function (U-PRCF),
  - UTRAN Position Calculation Function (U-PCF),
  - UTRAN Position Signal Measurement Function (U-PSMF),
  - UTRAN Position Radio Resource Management (U-PRRM),
  - UTRAN Position Related Communication Function (U-PRComF) for SAS centric mode.

The functions within the UTRAN are described in more detail in the following subclauses.

B.1 Internal Client Group

B.1.1 Internal UTRAN Location Client Function (U-LCF)

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

NOTE: There is not necessarily a requirement for a LCCF (Location Client Control Function) for the UTRAN Internal Client as is described for external clients in reference [13] (the system stage specification).

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

B.2 UTRAN System Handling group

B.2.1 UTRAN Location System Control Function (U-LSCF)

The UTRAN Location System Control Function (U-LSCF) **in RNC** is responsible for co-ordinating UE Positioning requests within the RNC handling entity. This function manages call-related and non-call-related UE Positioning requests and allocates network resources for handling them. This function "insulates" the Location clients in the Core Network from the detailed operation of the positioning method in order that the UTRAN may be used by several types of core network and with several positioning methods.

The U-LSCF provides flow control between simultaneous UE Positioning requests. Simultaneous UE Positioning 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 U-LSCF will select the appropriate positioning method based on the availability of resources and parameters of the UE Positioning request. The U-LSCF co-ordinates resources and activities needed to obtain data (e.g. Node B geographic co-ordinates) needed for the positioning method. It also records LCS RNC usage data for the location service request that may be passed to a Location System Recording Function (U-LSRF) or OA&M function in the Core Network.

If the positioning method requires the broadcast of system information, the LSCF initiates and maintains this activity through the Position Radio Co-ordination Function (U-PRCF). Broadcast information (such as the geographic co-ordinates of the Node Bs) may be required, for example, to support a Position Calculation Function (U-PCF) located in the UE. These broadcasts may also include other information (such as currently observable satellites) that may assist a UE in the use of external location services.

The information to be broadcast is selected based on the positioning methods offered for use by the LCS and the needs of the UE. 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 UE or the LMU may be selected based on the chosen positioning method.

The information to be broadcast could include, for example:

- identification and spreading codes of the neighbouring Node Bs (the channels that are used for measurements);
- Relative Time Difference (RTD), i.e. the timing offsets, asynchronicity between Node Bs, could be obtained from measurement results obtained by LMUs;
- roundtrip delay estimates in connected mode;
- the geographic position, co-ordinates, of the neighbouring Node Bs;
- the idle period places within the frame structure for multiple Node Bs;

- the local time-of-day.

Some of this information may be broadcast to support other UTRAN operations (e.g. handover). The function of the LSCF is to ensure information is broadcast when needed for the LCS operations and the LSCF may make use of other UTRAN processes to do so.

B.2.2 UTRAN Location System Operations Function (U-LSOF)

The UTRAN Location System Operations Function (U-LSOF) is responsible for provisioning of data, positioning capabilities, data related to clients and subscription (LCS client data and UE data), fault management and performance management of LCS within the RNC.

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

The Iur interface may pass messages relating to changes or reporting of the data associated with the LSOF in the RNC.

The Iub interface may pass messages relating to changes or reporting of the data associated with the LSOF in the Node B or the LMU.

The Uu interface may pass messages relating to changes or reporting of the data associated with the LSOF in the UE or the remote LMU. When the SAS is present, with either RNC or SAS centric mode, the U-LSOF may be split across SAS and SRNC.

B.2.3 UTRAN Location Information Relay Function (U-LIRF)

The UTRAN Location Information Relay Function (U-LIRF) is responsible for forwarding of Location Requests from to the LCS clients to the U-LSCFS and for forwarding of UE positioning estimates to the requesting LCS client. The U-LRIF also interfaces with the U-LSOF to obtain provisioned location information.

The U-LIRF communicates with the U-LSADF to handle assistance data requests received from the CN. The U-LIRF also forwards the UE positioning capability information and a coarse position estimate to the U-LSCFS.

B.2.4 UTRAN Location System Control Function in SAS (U-LSCFS)

The UTRAN Location System Control Function in SAS (U-LSCFS) is only used in the SAS centric mode. It performs similar tasks as the U-LSCF in the RNC centric mode, but instead of communicating directly with the LCS clients, it communicates with the U-LIRF in the SRNC.

B.2.5 UTRAN Location System Assistance Data Function (U-LSADF)

The UTRAN Location System Assistance Data Function (U-LSADF) is responsible for the handling location related assistance data within the RNC. This includes handling of location related assistance data requests from the CN and the broadcasting of location related assistance data, if requested by the U-LSCFS.

B.3 Positioning group

B.3.1 UTRAN Position Radio Co-ordination Function (U-PRCF)

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

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

The U-PRCF forwards the signal measurement data to the U-PCF.

It is the function of the U-PRCF to co-ordinate the sequence of activities and compensate for failures (if they occur) to provide the position estimate. In SAS centric mode the U-PRCF communicates to LMU, NodeB and UE via the U-PRComF.

B.3.2 UTRAN Position Calculation Function (U-PCF)

The UTRAN Position Calculation Function (U-PCF) is responsible for calculating the position of the UE. This function applies an algorithmic computation on the collected signal measurements to compute the final position estimate and accuracy.

The U-PCF may also support conversion of the position estimate between different geographic reference systems. It may obtain related data (e.g.: Node B geographic co-ordinates) needed for the calculation. There may be more than one calculating function available within, or associated with, the calculation function of the UTRAN.

In the cell ID based positioning method, the U-PCF shall determine the geographical co-ordinates corresponding to the cell(s) associated with the target UE.

The PCF is also responsible for estimating the accuracy of the position estimate. This accuracy estimate should include, for example, the effect of geometric dilution of precision (GDOP), the capabilities of the signal measuring hardware, the effects of multipath propagation and the effects of timing and synchronisation unknowns. The accuracy should be returned as a measure of distance in the same units as the position estimate. The accuracy zone may be reported as the axis and orientation of an ellipse surrounding the position estimate.

B.3.3 UTRAN Position Signal Measurement Function (U-PSMF)

The UTRAN Position Signal Measurement Function (U-PSMF) is responsible for performing and gathering uplink or downlink radio signal measurements for use in the calculation of a UE position. These measurements can be positioning related or ancillary.

There may be one or more PSMF within a UTRAN and they may be located at the UE, the Node B, or a separate LMU. The PSMF, generally, may provide measurement of signals (i.e. satellite signals) in addition to measurements of the UTRA radio transmissions. The measurements to be made will depend on the selected positioning method.

B.3.4 UTRAN Position Radio Resource Management (U-PRRM)

The UTRAN Position Radio Resource Management (U-PRRM) 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 U-PSMF does not degrade the QoS of other calls. The U-PRRM handles following functions:

- controlling the variation of the UL and DL signal power level due to the LCS application;
- calculating the DL and UL power/interference due to UE positioning operations;
- to admit/reject the new LCS requests;
- co-operating with Admission Control, and entities of the RRM (such as power control) to provide the system stability in terms of radio resources;
- controlling the RTD obtaining mechanism. It may also forward the results of the UTRAN GPS timing of cell frames or SFN-SFN Observed Time Difference (or any similar timing parameter) measurements to the PRCF (or PCF);

- controlling the IPDL mechanism for positioning measurements. This may include the overall control of the periodical measurement fulfilment. Co-ordination among RNCs (e.g. to assure non-overlapping idle periods) will be communicated through the Iur interface.

B.3.5 UTRAN Position Related Communication Function (U-PRComF)

The UTRAN Position Related Communication Function (U-PRComF) manages the collection of positioning measurements as requested by the U-PRCF.

The U-PRComF terminates the NBAP protocol for positioning related measurements requested from NodeB or LMU.

The U-PRComF terminates the RRC protocol for positioning related measurements requested from the UE.

B.4 Assignment of LCS Functional Entities to UTRAN Elements

Figure B.1, Figure B.2, Figure B.3 and tables B.1 and B.2 show the generic configuration for different positioning methods, including network-based, UE-based, UE-assisted and network-assisted methods. With this approach both UTRAN and the UE are able to measure the timing of signals and compute the UE position estimate. Depending on the applied positioning method it is possible to utilise the corresponding configuration containing all needed entities. For instance, if a network-based positioning method is applied, the entities that are involved in measuring the UE's signal and calculating its position estimate are allocated to the network elements of the access stratum. On the other hand, in case UE-based or network-assisted methods are used these entities should be allocated to the UE.

Table B.1: Example Allocation of LCS Functional Entities to Network Elements for RNC centric mode

UTRAN	UE	Node B	LMU	RNC	SAS
LCF	X			X	
LSCF				X	
PRCF				X	
PCF	X			X	X
PRRM				X	
PSMF	X	X	X		
LSOF	X	X	X	X	X

Table B.2: Example Allocation of LCS Functional Entities to Network Elements for SAS centric mode

UTRAN	UE	Node B	LMU	RNC	SAS
LCF	X			X	
LSCFS					X
LIRF				X	
PRCF					X
PCF	X				X
PRRM				X	
PSMF	X	X	X		
LSOF	X	X	X	X	X
PRComF				X	