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Foreword

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In the present document, modal verbs have the following meanings:

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- can** indicates that something is possible
- cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

- will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document
- will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document
- might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document specifies the stage 2 of the service-based architecture used for location services in the 5G system, and corresponding Network Functions (NFs), NF services and procedures, to meet the service requirements defined in TS 22.261 [3] and TS 22.071 [2].

Location Services specified in the present document include regulatory location services and commercial location services. The architecture and signalling procedures in NG-RAN are defined in TS 38.305 [9].

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: "Technical Specification Group Systems Aspects; Location Services (LCS)".
- [3] 3GPP TS 22.261: "Service requirements for next generation new services and markets; Stage 1".
- [4] 3GPP TS 23.271: "Functional stage 2 description of Location Services (LCS)".
- [5] 3GPP TS 43.059: "Functional Stage 2 description of Location Services in GERAN".
- [6] Void.
- [7] 3GPP TS 36.305: "Stage 2 functional specification of User Equipment (UE) positioning in E-UTRAN".
- [8] 3GPP TS 23.032: "Universal Geographical Area Description (GAD)".
- [9] 3GPP TS 38.305: "Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".
- [10] 3GPP TS 23.167: "IP Multimedia Subsystem (IMS) emergency sessions".
- [11] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".
- [12] 3GPP TS 29.572: "5G System; Location Management Services; Stage 3".
- [13] OMA MLP TS: "Mobile Location Protocol", [<http://www.openmobilealliance.org>].
- [14] OMA RLP TS: "Roaming Location Protocol", [<http://www.openmobilealliance.org>].
- [15] 3GPP TS 38.455: "NG-RAN; NR Positioning Protocol A (NRPPa)".
- [16] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".
- [17] 3GPP TS 25.305: "Stage 2 functional specification of User Equipment (UE) positioning in UTRAN".
- [18] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".
- [19] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

- [20] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".
- [21] 3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".
- [22] ETSI ES 282 004: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Functional Architecture; Network Attachment Sub-System (NASS)".
- [23] ITU-T Recommendation E.164: "The international public telecommunication numbering plan".
- [24] 3GPP TS 23.222: "Common Application Programming Interface (API) framework for 3GPP northbound APIs".
- [25] RFC 2396: "Uniform Resource Identifiers".
- [26] RFC 3261: "SIP: Session Initiation Protocol".
- [27] 3GPP TS 23.228: "IP multimedia subsystem (IMS)".
- [28] 3GPP TS 23.003: "Numbering, addressing and identification".
- [29] 3GPP TS 29.002: "Mobile Application Part (MAP) specification".
- [30] 3GPP TS 32.271: "Telecommunication management; Charging management; Location Services (LCS) charging".
- [31] 3GPP TS 32.298: "Telecommunication management; Charging management; Charging Data Record (CDR) parameter description".
- [32] Void.
- [33] 3GPP TS 29.571: "5G System; Common Data Types for Service Based Interfaces; Stage 3".
- [34] 3GPP TS 29.171: "Location Services (LCS); LCS Application Protocol (LCS-AP) between the Mobile Management Entity (MME) and Evolved Serving Mobile Location Centre (E-SMLC); SLs interface".
- [35] 3GPP TS 29.122: "T8 reference point for Northbound APIs".

3 Definitions and Abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

LCS Client: entity that interacts with GMLC for the purpose of obtaining location information for one or more UEs. The LCS Client may reside in the UE.

For the purposes of the present document, the following terms and definitions given in TS 23.271 [4] apply:

Call Related: see TS 23.271 [4].

Codeword: see TS 23.271 [4].

Current Location: see TS 23.271 [4].

Deferred location request: see TS 23.271 [4].

Immediate location request: see TS 23.271 [4].

Last Known Location: see TS 23.271 [4].

LCS (LoCation Services): see TS 23.271 [4].

Location Estimate: see TS 23.271 [4].

Pseudonym: see TS 23.271 [4].

Pseudonym mediation device: Functionality that verifies pseudonyms to verinym.

Requestor: see TS 23.271 [4].

Requestor Identity: see TS 23.271 [4].

Response Method: for LCS Client using the OMA MLP protocol. Detail see TS 23.271 [4].

Service Type: see TS 23.271 [4].

Target UE: see TS 23.271 [4].

Velocity: see TS 23.271 [4].

Verinym: see TS 23.271 [4].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

APN	Access Point Name
APN-NI	APN Network Identifier
EDT	Early Data Transmission
E-SMLC	Evolved Serving Mobile Location Centre
GMLC	Gateway Mobile Location Centre
HGMLC	Home GMLC
LCS	LoCation Services
LDR	Location Deferred Request
LMF	Location Management Function
LPI	LCS Privacy Indicator
LRF	Location Retrieval Function
MO-LR	Mobile Originated Location Request
MT-LR	Mobile Terminated Location Request
NI-LR	Network Induced Location Request
PMD	Pseudonym mediation device functionality
POI	Privacy Override Indicator
TNAN	Trusted Non-3GPP Access Network
UNAN	Untrusted Non-3GPP Access Network
VGMLC	Visited GMLC

4 Architecture Model and Concepts

4.1 General Concepts

A general description of location services and service requirements are given in the specification TS 22.071 [2]. Support of location services for GERAN, UTRAN and E-UTRAN access networks is described in TS 23.271 [4], TS 43.059 [5], TS 25.305 [17] and TS 36.305 [7].

The positioning of a UE can be supported by RAT dependent position methods, which rely on for example 3GPP RAT measurements obtained by a target UE and/or on measurements obtained by an Access Network of 3GPP RAT signals transmitted by a target UE. Positioning of a UE can also be supported by RAT independent position methods which may rely on non-RAT measurements obtained by a UE and/or on other information.

The positioning of a UE can be performed by either 3GPP access network or non-3GPP access network. A proper access type shall be determined to assure that the positioning result can fulfil the requested QoS and operator policy.

Location information for one or multiple target UEs may be requested by and reported to an LCS client or an AF within or external to a PLMN, or a control plane NF within a PLMN. Location information contained in the location request and location information contained in the location response are defined in clause 5.5.

For location request from LCS client (neither in the UE nor in the NG-RAN) or AF external to a PLMN, privacy verification of the target UE shall be enabled to check whether it is allowed to acquire the UE location information based on UE LCS privacy profile and whether the LCS client or the AF is authorised to use the location service as defined in clause 5.4. Additionally, UEs may optionally support privacy notification and verification on behalf of a user. Privacy override is also supported for regulatory LCS services according to local regulation.

The capabilities of a target UE to support LCS may be signalled by the UE to a serving PLMN at the AS, NAS and application (positioning protocol) levels to enable use of position methods supported by the UE.

To provide Location Service in the EPC interworking scenario, an EPC and 5GC common interface shall be used for the location request from LCS client or AF.

4.1a Types of Location Request

4.1a.1 Network Induced Location Request (NI-LR)

With a Network Induced Location Request (NI-LR), a serving AMF for a UE initiates location of the UE for some regulatory service (e.g. an emergency call from the UE).

4.1a.2 Mobile Terminated Location Request (MT-LR)

With a Mobile Terminated Location Request (MT-LR), an LCS client or AF external to or internal to a serving PLMN sends a location request to the PLMN (which may be the HPLMN or VPLMN) for the location of a target UE.

4.1a.3 Mobile Originated Location Request (MO-LR)

With a Mobile Originated Location Request (MO-LR), a UE sends a request to a serving PLMN for location related information for the UE.

4.1a.4 Immediate Location Request

With an immediate location request, an LCS client or AF sends or instigates a location request for a target UE (or group of target UEs) and expects to receive a response containing location information for the target UE (or group of target UEs) within a short time period which may be specified using QoS. An immediate location request may be used for an NI-LR, MT-LR or MO-LR.

4.1a.5 Deferred Location Request

With a deferred location request, an LCS client or AF sends a location request to a PLMN for a target UE (or group of target UEs) and expects to receive a response containing the indication of event occurrence and location information if requested for the target UE (or group of target UEs) at some future time (or times), which may be associated with specific events associated with the target UE (or group of target UEs). In this version of the specification, only deferred location requests for an MT-LR are supported.

4.1a.5.1 Types of event

The following types of event are defined for a deferred location request.

- a) UE availability: Any event in which the 5GCN has established a contact with the UE. This event is considered to be applicable when the UE is temporarily unavailable due to inaction by the user, or for temporarily loss of radio connectivity or IMSI detach and so on. The UE Available event only requires one response to an LCS client/AF and after this response, the UE Available event is concluded.

- b) Area: An event where the UE enters, leaves or remains within a pre-defined geographical area. At least one type of area event can be defined (i.e. entering, leaving or remaining within the area). The LCS client or AF may define the target area as a geographical area or as a geopolitical name of an area. The PLMN may translate and define the target area as the identities of one or more radio cells or tracking areas. The area event may be reported one time only, or multiple times. The area event report shall contain an indication of the event occurrence. The location estimate may be included in the report. If an area event is detected by the UE but an event report cannot be sent (e.g. because the UE cannot access the network or due to a minimum reporting interval), a report shall be sent later when possible irrespective of whether the area event still applies for the current UE location. Area event reporting is controlled by a minimum and a maximum reporting time. The minimum reporting time defines the minimum allowed time between successive area events. The maximum reporting time defines the maximum time between successive reports. When a UE sends a report due to expiration of the maximum reporting time, the UE indicates expiration of the maximum reporting time as the trigger event. The maximum reporting time enables the AF, LCS client and HGMLC to remain aware of continuing support by the UE for the area event (e.g. to detect if area event reporting may have been aborted due to UE power off).
- c) Periodic Location: An event where a defined periodic timer expires in the UE and activates a location report. If a periodic event is detected by the UE but an event report cannot be sent (e.g. because the UE cannot access the network temporarily), a report shall be sent later when possible and the periodic timer for the next event shall then be started. The reporting duration for periodic location shall equal the requested number of reports multiplied by the periodic interval even when reports are delayed.
- d) Motion: An event where the UE moves by more than some predefined straight line distance from a previous location. The motion event may be reported one time only, or multiple times. The motion event report shall contain an indication of the event occurrence. A location estimate may be included in the report if requested by the LCS client or AF. For successive motion event reports, motion is determined relative to the UE location corresponding to the immediately preceding event report (including an event report triggered by expiration of the maximum reporting time). If a motion event is detected by the UE but an event report is deferred (e.g. because the UE cannot access the network temporarily), a report shall be sent later when possible irrespective of whether the motion event still applies to the current UE location. Motion reporting is controlled by a minimum and a maximum reporting time. The minimum reporting time defines the minimum allowed time between successive event reports. The maximum reporting time defines the maximum time between successive reports. When a UE sends a report due to expiration of the maximum reporting time, the UE indicates expiration of the maximum reporting time as the trigger event. The maximum reporting time enables the AF, LCS client and HGMLC to remain aware of continuing support by the UE for the motion event (e.g. to detect if motion event reporting may have been aborted due to UE power off).

4.1b LCS Quality of Service

LCS Quality of Service is used to characterise the location request. It can either be determined by the operator or determined based on the negotiation with the LCS client or the AF. It is optional for LCS client or the AF to provide the LCS Quality of Service in the location request.

LCS Quality of Service information is characterised by 3 key attributes:

- LCS QoS Class as defined below.
- Accuracy: i.e. Horizontal Accuracy (see clause 4.3.1 of TS 22.071 [2]) and Vertical Accuracy (see clause 4.3.2 of TS 22.071 [2]).
- Response Time (e.g. no delay, low delay or delay tolerant as described in clause 4.3.3 of TS 22.071 [2]).

The LCS QoS Class defines the degree of adherence by the Location Service to another quality of service parameter (Accuracy), if requested. The 5G system shall attempt to satisfy the other quality of service parameter regardless of the use of QoS Class. There are 2 LCS QoS Classes:

- Best Effort Class: This class defines the least stringent requirement on the QoS achieved for a location request. If a location estimate obtained does not fulfil the other QoS requirements, it should still be returned but with an appropriate indication that the requested QoS was not met. If no location estimate is obtained, an appropriate error cause is sent.

- Assured Class: This class defines the most stringent requirement on the accuracy achieved for a location request. If a location estimate obtained does not fulfil the other QoS requirements, then it shall be discarded, and an appropriate error cause shall be sent.

For LCS client, it may indicate accuracy defined in TS 29.572 [12], tables 6.1.6.3.2-1 and 6.1.6.3.5-1. For AF, it may either indicate the accuracy defined in TS 29.572 [12], table 6.1.6.3.2-1, or indicate a particular value e.g. PLMN ID defined in TS 29.122 [35], table 5.3.2.4.7-1.

4.2 Architectural Reference Model

4.2.1 Non-roaming reference architecture

Figure 4.2.1-1 shows an architectural reference model for 5GS LCS for a non-roaming UE in reference point representation.

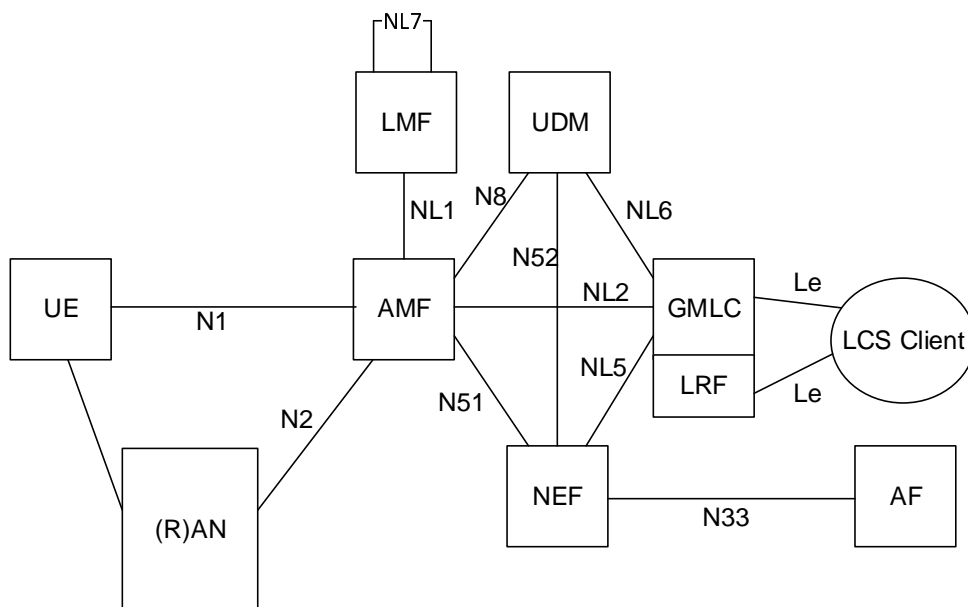


Figure 4.2.1-1: Non-roaming reference architecture for Location Services in reference point representation

NOTE 1: (R)AN represents NG-RAN, trusted non-3GPP access or untrusted non-3GPP access.

NOTE 2: Reference point interface related to charging functionality is not shown in this specification.

Figure 4.2.1-2 shows an architectural reference model for 5GS LCS for a non-roaming UE in SBI representation.

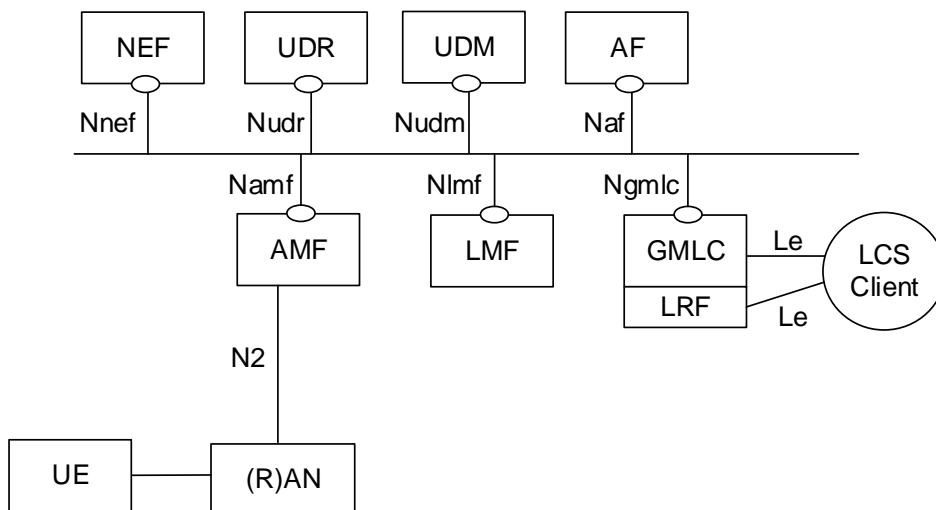


Figure 4.2.1-2: Non-roaming reference architecture for Location Services in SBI representation

4.2.2 Roaming reference architecture

Figure 4.2.2-1 shows an architectural reference model for 5GS LCS for a roaming UE in reference point representation.

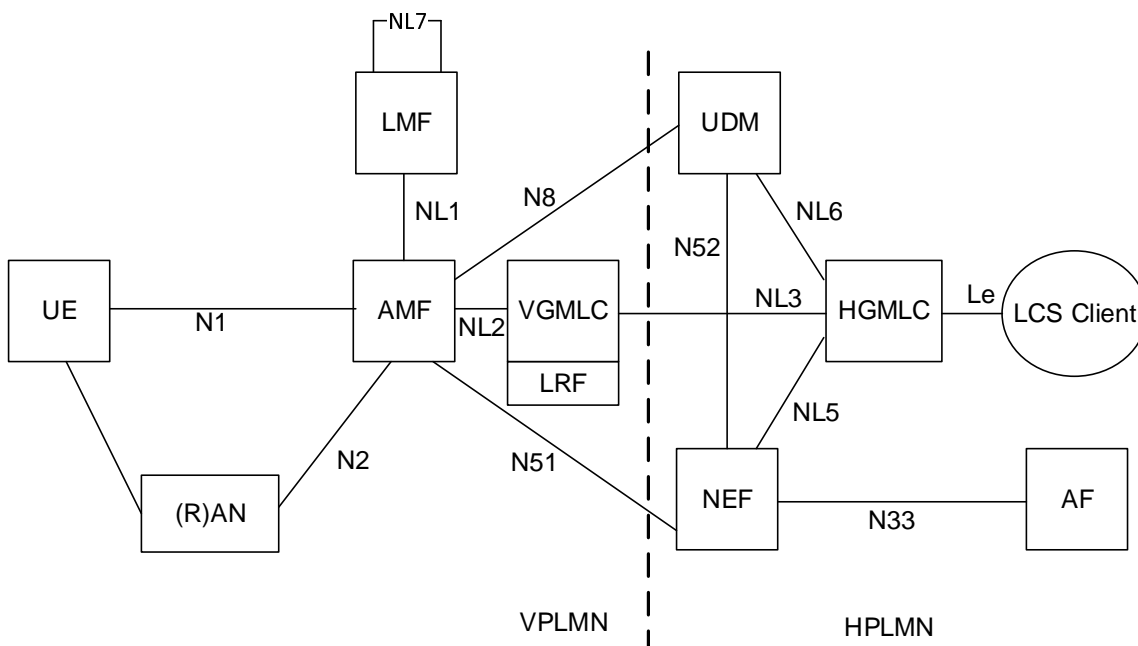


Figure 4.2.2-1: Roaming reference architecture for Location Services in reference point representation

NOTE 1: (R)AN represents NG-RAN, trusted non-3GPP access or untrusted non-3GPP access.

NOTE 2: Reference point interface related to charging functionality is not shown in this specification.

Figure 4.2.2-2 shows an architectural reference model for 5GS LCS for a roaming UE in SBI representation.

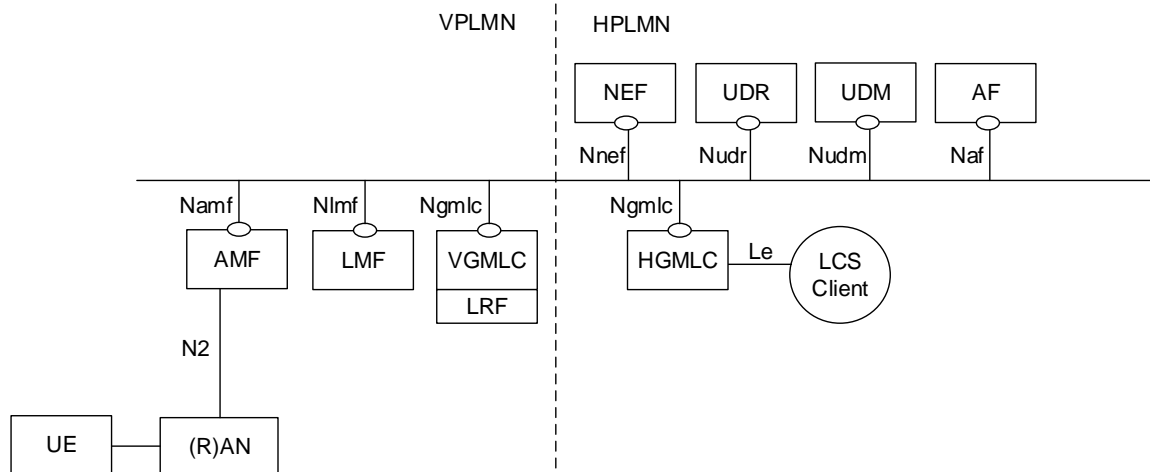


Figure 4.2.2-2: Roaming reference architecture for Location Services in SBI representation

4.2a Interconnection between 5GC and EPC

4.2a.1 General

For MT-LR Location Request, when a LCS service request is received at 5GC GMLC, the target UE may be served by either 5GC or EPC. An EPC/5GC common interface is used between the LCS Client and the 5GC GMLC to enable the location service request being handled based on whether the target UE is served by EPC or 5GC. The AF initiates the service request to the 5GC GMLC via NEF.

NOTE: The LCS Client doesn't know if UE is currently served by EPC or 5GC.

For MT-LR Location Request, the 5GC interconnection with EPC happens:

- when an LCS service request is received by the 5GC GMLC and the target UE is served by EPC in non-roaming case;
- when an LCS request is received by the 5GC GMLC in the HPLMN of the target UE and the target UE is served by EPC in the VPLMN in roaming case.

4.2a.2 Non-roaming architecture

Figure 4.2a.2-1 represents the non-roaming architecture of Location Services for interconnection between 5GC and EPC.

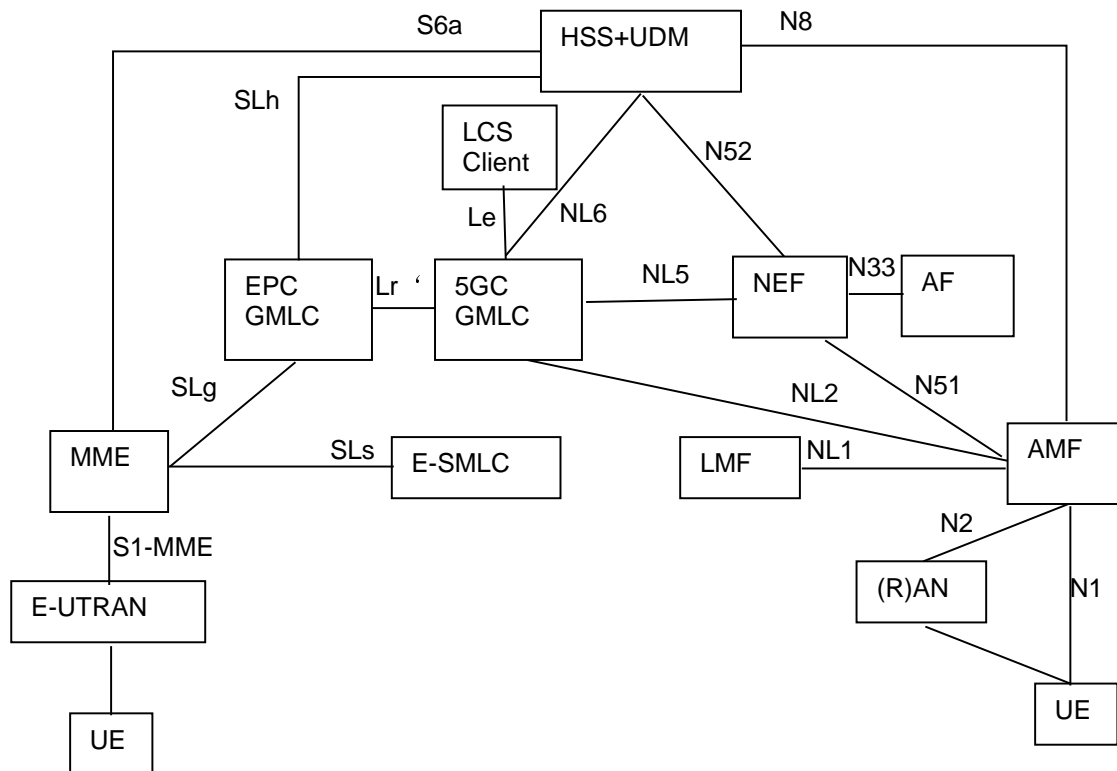


Figure 4.2a.2-1: Non-roaming architecture of interconnection between 5GC and EPC

NOTE 1: EPC GMLC and 5GC GMLC can be collocated in implementation, in such case, Lr' is not needed.

NOTE 2: For this release, Lr' is not standardized.

4.2a.3 Roaming architecture

Figure 4.2a.2-1 and Figure 4.2a.2-2 represent the Roaming architecture of interconnection between 5GC and EPC.

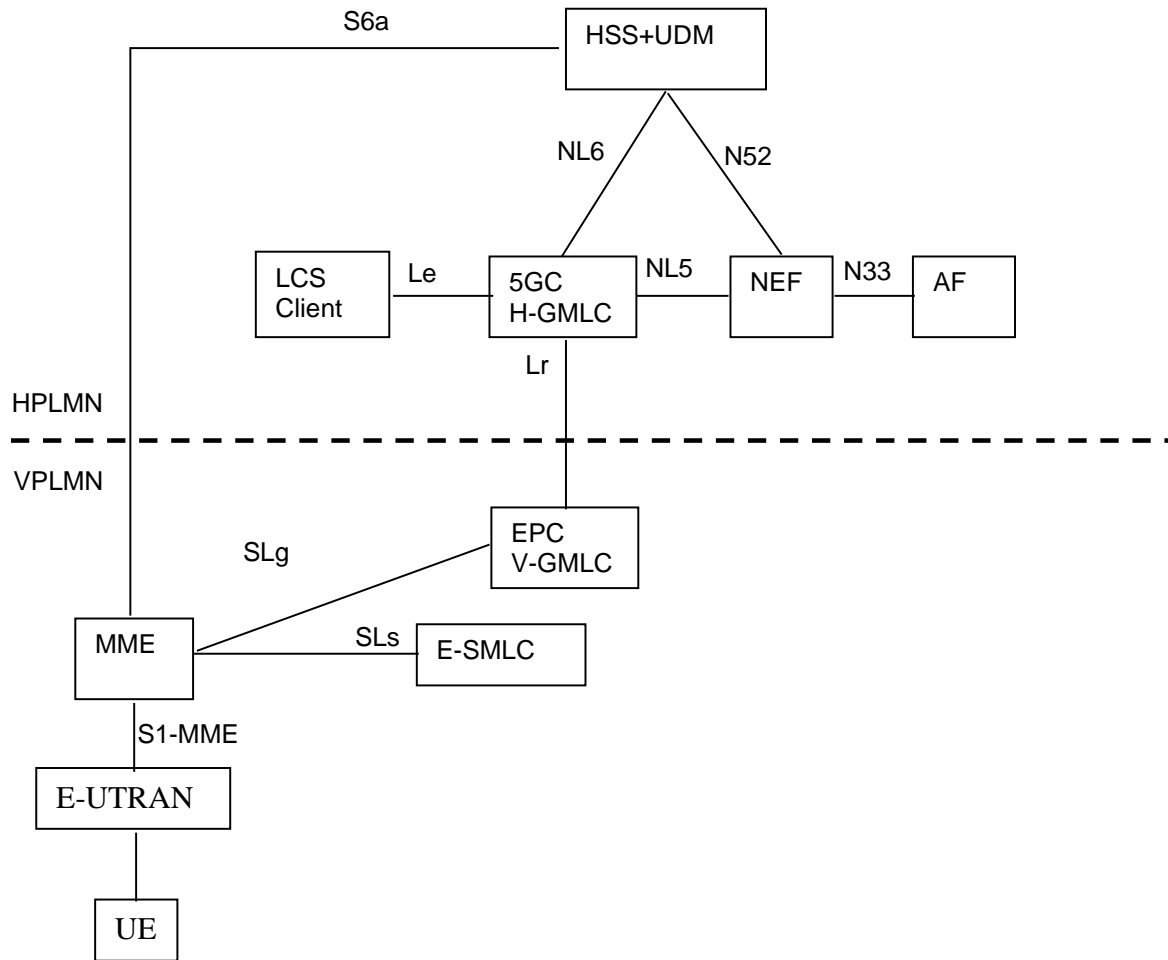


Figure 4.2a.2-1: Roaming architecture of Location Services for interconnection between 5GC and EPC (5GC GMLC and EPC GMLC are separately deployed in VPLMN)

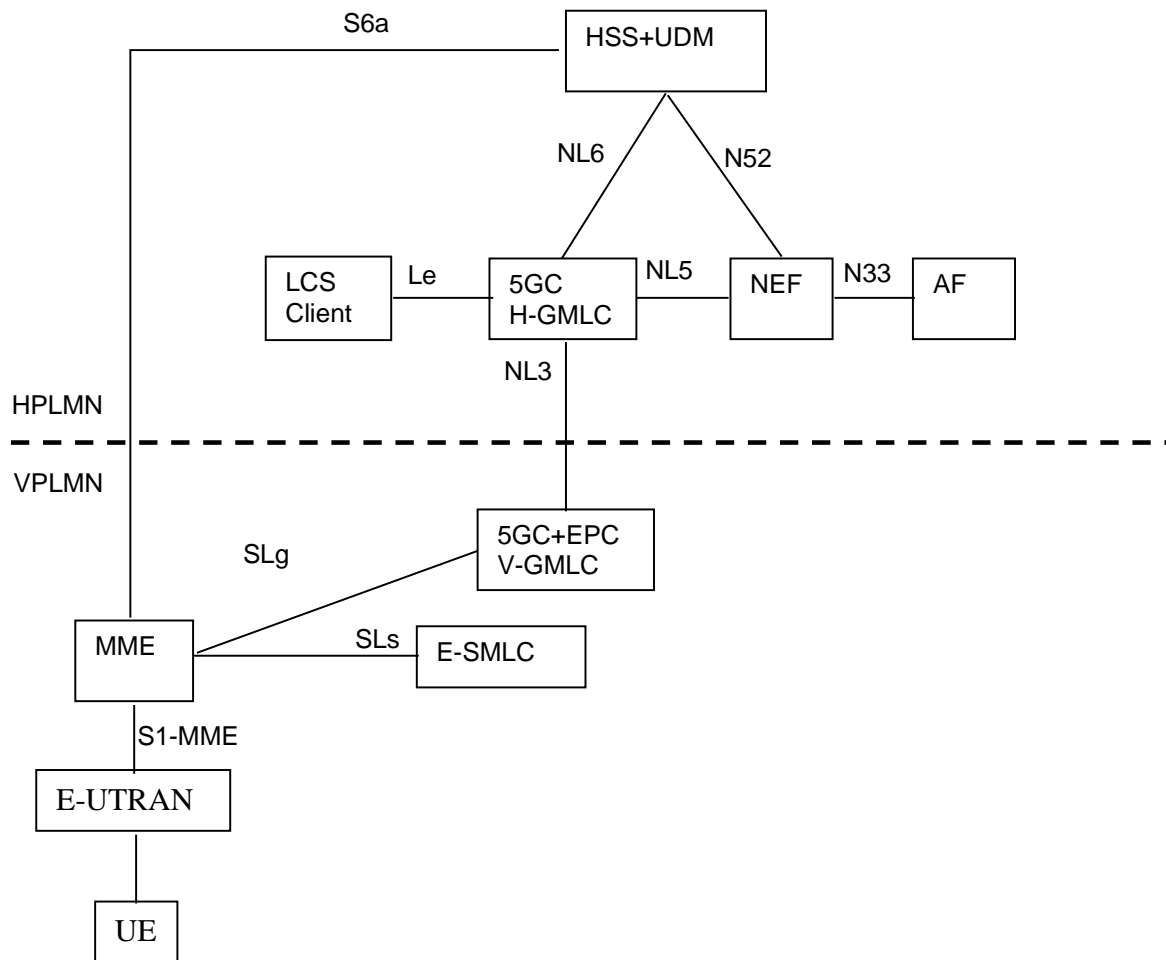


Figure 4.2a.2-2: Roaming architecture of Location Services for interconnection between 5GC and EPC (5GC GMLC and EPC GMLC are co-located in VPLMN)

4.2b Positioning methods

The LCS feature utilises one or more positioning methods in order to determine the location of user equipment (UE). Determining the position of a UE involves two main steps:

- Radio signal measurements or non-RAT measurements; and
- Position estimate computation based on the measurements.

The positioning methods for 3GPP access are described in clause 5.2.

The positioning methods for non-3GPP access are described in clause 5.3.1.

4.3 Functional description of LCS per network function

4.3.1 Access Network

The Access Network is involved in the handling of various positioning procedures including positioning of a target UE, provision of location related information not associated with a particular target UE and transfer of positioning messages between an AMF or LMF and a target UE. The Access Network shall support determination of location estimates in geographical co-ordinates as defined in TS 23.032 [8].

In this version of the specification, location services are supported for NG-RAN, trusted non-3GPP access and untrusted non-3GPP access.

The LCS specific functionalities of the radio access network elements are specified in TS 38.305 [9] for NG-RAN.

4.3.2 LCS Clients, Application Functions and Network Functions

AFs and NFs may access LCS services from a GMLC in the same trust domain (e.g. in the same PLMN) using the Ngmlc interface or Event Exposure with location information from an AMF in the same trust domain using the Namf interface.

LCS Clients may access LCS services from a GMLC (e.g. HGMLC) using the Le reference point.

External AFs may access LCS services from an NEF using Nnef interface or CAPIF API. The CAPIF and associated API provider domain functions are specified in TS 23.222 [24].

4.3.3 Gateway Mobile Location Centre, GMLC

The Gateway Mobile Location Centre (GMLC) contains functionality required to support LCS. In one PLMN, there may be more than one GMLC.

A GMLC is the first node an external LCS client accesses in a PLMN (i.e. the Le reference point is supported by the GMLC). AFs and NFs may access GMLC directly or via NEF. The GMLC may request routing information and/or target UE privacy information from the UDM via the Nudm interface. After performing authorization of an external LCS Client or AF and verifying target UE privacy, a GMLC forwards a location request to either a serving AMF using Namf interface or to a GMLC in another PLMN using the Ngmlc interface in the case of a roaming UE.

The target UE's privacy profile settings shall always be checked in the UE's home PLMN prior to delivering a location estimate.

The "Visited GMLC" (VGMLC) is the GMLC, which is associated with the serving node of the target UE.

The "Home GMLC" (HGMLC) is the GMLC residing in the target UE's home PLMN, which is responsible for the control of privacy checking of the target UE.

Additional functions which may be performed by a GMLC to support location services include the following.

- At an HGMLC, determine the serving AMF for a target UE when there is more than one serving AMF.
- At an HGMLC, determine whether to attempt a second location request for a target UE from a different AMF when location information returned by a first AMF does not meet QoS requirements and there is more than one serving AMF.
- At an HGMLC, support location requests from an external LCS client or NEF for a 5GC-MT-LR and deferred 5GC-MT-LR for periodic, triggered and UE available location events.
- At an HGMLC, forward location requests for a roaming UE to a VGMLC or serving AMF in the VPLMN based on deployment configurations.
- At an HGMLC, receive event reports from a VGMLC or LMF for a deferred 5GC-MT-LR for periodic or triggered location and return to an external LCS Client or NEF.
- At an HGMLC, support cancelation of a periodic or triggered location.
- At an HGMLC, receive location information from a VGMLC for a 5GC-MO-LR and forwards to an LCS Client or an AF (via NEF) if requested by the UE.
- At a VGMLC, receive location requests from an HGMLC for a roaming UE and forward to a serving AMF.
- At a VGMLC, receive event reports from an LMF for a deferred 5GC-MT-LR for periodic or triggered location for a roaming UE and forward to an HGMLC.
- At a VGMLC, receive location information from an AMF for a 5GC-MO-LR and forwards to an HGMLC.

- At an HGMLC, reject the LCS request coming from a LCS client, e.g. when the number of Target UEs in the LCS request exceeds the Maximum Target UE Number of such client.
- At an HGMLC, allocate the reference number for each location request from an external LCS client for LDR.
- At an HGMLC, assign the pseudonym if pseudonym indicator is received in the service request and transfer it to external LCS client, e.g. when core network provides the UE's location information to LCS client. Resolve the verinym from the pseudonym, if it is received from the LCS client.
- At an HGMLC, resolve group identifier to identifier of individual UEs and aggregate responses to LCS Client or NEF during bulk operation procedure.

4.3.4 Location Retrieval Function, LRF

The Location Retrieval Function (LRF) may be collocated with a GMLC or separate and is responsible for retrieving or validating location information, providing routing and/or correlation information for a UE which has initiated an IMS emergency session. The information is provided by an LRF to an E-CSCF. For more details, refer to TS 23.167 [10].

4.3.5 UE

A target UE may support positioning according to four different modes:

- UE assisted mode (the UE obtains location measurements and sends the measurements to another entity (e.g. an LMF) to compute a location);
- UE based mode (the UE obtains location measurements and computes a location estimate making use of assistance data provided by serving PLMN);
- standalone mode (the UE obtains location measurements and computes a location estimate without making use of assistance data provided by serving PLMN);
- network based mode (a serving PLMN obtains location measurements of signals transmitted by a target UE and computes a location estimate).

NOTE: The transmission of UE signals for network based mode may or may not be transparent to the UE.

Positioning procedures used by a UE for NG-RAN access are described in TS 38.305 [9].

A limited set of UE positioning capabilities can be transferred to the 5GCN during registration of the UE as described in TS 24.501 [11]. Some of these positioning capabilities may be transferred subsequently to an LMF as described in TS 29.572 [12]. UE positioning capabilities may also be transferred directly to a location server (e.g. LMF).

Additional functions which may be supported by a UE to support location services include the following.

- Support location requests received from a network for 5GC-MT-LR, 5GC-NI-LR or a deferred 5GC-MT-LR for periodic or triggered location.
- Support location requests to a network for a 5GC-MO-LR.
- Support privacy notification and verification for a 5GC-MT-LR or deferred 5GC-MT-LR for periodic or triggered location.
- Send updated privacy requirements to a serving AMF (for transfer to a UDR via UDM).
- Support periodic or triggered location reporting to an LMF.
- Support change of a serving LMF for periodic or triggered location reporting.
- Support cancelation of periodic or triggered location reporting.
- Support multiple simultaneous location sessions.
- Support the reception of unciphered and/or ciphered assistance data broadcast by NG-RAN.
- Support the reception of ciphering keys for the assistance data from the AMF.

4.3.6 UDM

The UDM contains LCS subscriber LCS privacy profile and routing information. The UDM is accessible from an AMF, GMLC or NEF via the Nudm interface.

4.3.7 Access and Mobility Management Function, AMF

The AMF contains functionality responsible for managing positioning for a target UE for all types of location request. The AMF is accessible to the GMLC and NEF via the Namf interface, to the RAN via the N2 reference point and to the UE via the N1 reference point.

Functions which may be performed by an AMF to support location services include the following.

- Initiate an NI-LR location request for a UE with an IMS emergency call.
- Receive and manage location requests from a GMLC for a 5GC-MT-LR and deferred 5GC-MT-LR for periodic, triggered and UE available location events.
- Receive and manage location requests from a UE for a 5GC-MO-LR.
- Receive and manage Event Exposure request for location information from an NEF.
- Select an LMF.
- Receive updated privacy requirements from a UE and transfer to a UDR via UDM.
- Support cancelation of periodic or triggered location reporting for a target UE.
- Support change of a serving LMF for periodic or triggered location reporting for a target UE.
- When assistance data is broadcast by 5GS in ciphered form, the AMF receives ciphering keys from the LMF and forwards to suitably subscribed UEs using mobility management procedures.

4.3.8 Location Management Function, LMF

The LMF manages the overall co-ordination and scheduling of resources required for the location of a UE that is registered with or accessing 5GCN. It also calculates or verifies a final location and any velocity estimate and may estimate the achieved accuracy. The LMF receives location requests for a target UE from the serving AMF using the Nlmf interface. The LMF interacts with the UE in order to exchange location information applicable to UE assisted and UE based position methods and interacts with the NG-RAN, N3IWF or TNAN in order to obtain location information.

The LMF shall determine the result of the positioning in geographical co-ordinates as defined in TS 23.032 [8]. If requested and if available, the positioning result may also include the velocity of the UE.

Additional functions which may be performed by an LMF to support location services include the following.

- Support a request for a single location received from a serving AMF for a target UE.
- Support a request for periodic or triggered location received from a serving AMF for a target UE.
- Determine position methods based on UE and PLMN capabilities, QoS, UE connectivity state per access type, LCS Client type and optionally service type.
- Report UE location estimates directly to a GMLC for periodic or triggered location of a target UE.
- Support cancelation of periodic or triggered location for a target UE.
- Support the provision of broadcast assistance data to UEs via NG-RAN in ciphered or unciphered form and forward any ciphering keys to subscribed UEs via the AMF.
- Support change of a serving LMF for periodic or triggered location reporting for a target UE.

4.3.9 Network Exposure Function, NEF

An NEF provides a means of accessing location services by an external AF or internal AF. AFs access location services from an NEF using an API. Depending on QoS requirements, an NEF can forward a location request to a GMLC or request an event exposure for location information from serving AMF (optionally via a UDM). When event exposure via AMF is used, an NEF may request routing information and/or target UE privacy information from the UDM via the Nudm interface.

Additional functions which may be performed by an NEF to support location services include the following.

- Support location requests from an AF for immediate location and for deferred periodic and triggered location events.
- Support location information exposure to an AF based on the location request.
- Support determination of GMLC or AMF based on e.g. the QoS requirements from AF, type of the location request.
- Select the serving AMF for a target UE when there is more than one serving AMF.
- Determine whether to attempt a second location request for a target UE from a different AMF when location information returned by a first AMF does not meet QoS requirements and there is more than one serving AMF.
- Support UE LCS privacy profile provision from the AF.
- Support suspending and cancellation of a periodic or triggered location request.
- Support authorization of LCS request from the AF.
- Support rejecting the LCS request coming from an AF, e.g. when the number of Target UEs in the LCS request exceeds the Maximum Target UE Number of such client.
- Support allocating the reference number for each location request from an AF for LDR.

4.3.10 Unified Data Repository, UDR

The UDR contains privacy data information for target UEs and may be updated by a serving AMF via UDM with new privacy information received from a UE.

4.4 Reference Point to Support Location Services

4.4.1 Le Reference Point

The Le reference point supports location requests sent by an LCS Client to a GMLC or LRF.

The Le reference point may be supported using the Mobile Location Protocol (MLP) defined by OMA [13].

4.4.2 NL3 Reference Point

The NL3 reference point supports location requests forwarded by an HGMLC to a VGMLC.

4.4.3 N1 Reference Point

The N1 reference point supports transfer of supplementary services messages between a serving AMF and target UE to support privacy notification and verification and change of UE privacy preference. The N1 reference point also supports transfer of positioning protocol messages and location event reports between a target UE and an LMF via a serving AMF. The N1 reference point supports the transfer of ciphering keys from an AMF to a suitably subscribed UE to enable the UE to receive ciphered broadcast assistance data. All messages sent over the N1 reference point for support of location services are encapsulated in NAS Transport messages as defined in TS 24.501 [11].

4.4.4 N2 Reference Point

The N2 reference point supports transfer of positioning messages, via an AMF, between an LMF and a RAN node, or N3IWF in the case of untrusted non-3GPP access. The N2 reference point also supports transfer of messages, via an AMF, from an LMF to an NG-RAN node, which carry assistance data to be broadcast by the NG-RAN node. Positioning messages relevant to the N2 interface are defined in TS 38.455 [15].

4.4.5 Void

4.4.6 NL5 Reference Point

The NL5 reference point supports location requests sent by an NEF or other NF to a GMLC.

4.4.7 NL2 Reference Point

The NL2 reference point supports location requests sent by a GMLC to a serving AMF for a target UE.

Messages for the NL2 reference point are defined in TS 29.518 [16].

4.4.8 NL6 Reference Point

The NL6 reference point supports queries from an HGMLC to a UDM for privacy subscription information for a target UE and routing information for a target UE.

4.4.9 N51 Reference Point

The N51 reference point supports queries from an NEF to a serving AMF for the location of a target UE.

Messages for the N51 reference point are defined in TS 29.518 [16].

4.4.10 NL1 Reference Point

The NL1 reference point supports location requests for a target UE sent from a serving AMF for the target UE to an LMF. Location requests are supported for immediate location and for deferred location for periodic or triggered location events.

The NL1 reference point also supports the transfer from an LMF to an AMF of ciphering keys and associated data that enable deciphering by suitably subscribed UEs of ciphered broadcast assistance data.

Messages for the NLI reference point are defined in in TS 29.518 [16] and TS 29.572 [12].

4.4.11 N52 Reference Point

The N52 reference point supports queries from an NEF to a UDM for privacy subscription information for a target UE and routing information for a target UE. The N52 interface also supports a request from an NEF to a UDM to forward a location request from the NEF to a serving AMF for the target UE.

4.4.12 NL7 Reference Point

The NL7 reference point supports location context transfer between two LMFs.

4.5 Service Based Interfaces to Support Location Services

The 5GS LCS architecture contains the following service-based interfaces for Location Services:

Nlmf: Service-based interface exhibited by LMF.

Ngmlc: Service-based interface exhibited by GMLC.

5 High Level Features

5.1 LMF Selection

LMF selection functionality is used by the AMF to determine an LMF for location estimation of the target UE. If an LMF ID is available in the UE location context or provided by the UE, the AMF should first evaluate if the LMF identified by the LMF ID can be used. The LMF selection functionality is also supported by the LMF if it determines that it is unsuitable or unable to support location for the current UE access network or serving cell for the deferred 5G-MT-LR procedure for periodic, or triggered location events.

LMF reselection is a functionality supported by AMF when necessary, e.g. due to UE mobility.

The AMF selects a new LMF if:

- AMF determines that LMF identified by the LMF ID cannot be used; or
- the LMF ID is not available in the UE location context; or
- the LMF ID is not provided by the UE.

The LMF selection may be performed at the AMF or LMF based on the locally available information i.e. LMF profiles are configured locally at AMF or LMF, or by querying NRF.

LMF selection is performed when:

- a location request is received at the AMF and the AMF determines to use the LMF for UE position estimation; or
- the subscribed UE event reporting is received.

The following factors may be considered during the LMF selection:

- LCS client type.
- Requested Quality of Service information, e.g.:
 - LCS accuracy,
 - Response time (latency),
- Access Type (3GPP /N3GPP).

NOTE: Location methods may differ depending on the Access Type, e.g. in the case of WLAN Access Location determination may just correspond to retrieval of IP addressing information from the N3IWF/TNGF; As another example, for Wireline access, Location determination may just correspond to retrieval of geo coordinates corresponding to a GLI as defined in TS 23.316 [21] clause 4.7.8 or a HFC Node ID.

- RAT type (i.e. 5G NR or eLTE) and/or the serving AN node (i.e. gNB or NG-eNB) of the target UE.
- RAN configuration information.
- LMF capabilities.
- LMF load.
- LMF location.
- Indication of either a single event report or multiple event reports.
- Duration of event reporting.
- Network slicing information, e.g. S-NSSAI and/or NSI ID.

5.1a GMLC Discovery and Selection

More than one GMLC in the HPLMN can serve the location requests for a single UE. GMLC discovery and selection functionality is supported by AMF, LMF, NEF, LCS client and GMLC.

A LCS client may be configured with GMLC address(es). It may also determine the GMLC address by performing a DNS query.

A NEF, LMF, AMF or GMLC may be configured with GMLC address(es). Those NF may also query the NRF to get GMLC address(es).

In the following scenarios, information about the GMLC instance may be provided by UE, in such case, this GMLC instance is used:

- In the deferred MT-LR procedure, when UE reports the detected event to the AMF, it may also include the (H)GMLC address.
- In the MO-LR procedure, when UE initiates the LCS service request, it may also include the (H)GMLC address if the location estimation is reported to the (H)GMLC.

5.2 3GPP access specific aspects

When 3GPP access type is selected, the positioning methods for 3GPP access defined in TS 38.305 [9] apply.

Access Type Selection for LCS Service is defined in clause 5.3.2.

5.3 Non-3GPP Access Specific Aspects

5.3.1 Location Information for Non-3GPP Access

If the UE registered to non-3GPP access, following information can be regarded as UE location information:

Table 5.3.1-1: Supported UE location information of non-3GPP access

	Untrusted non-3GPP Access	Trusted non-3GPP Access	Wireline Access
UE Side N5CW device Side for Trusted WLAN Access 5G-RG side for Wireline Access	UE local IP address, In the case of WLAN access, BSSID of the attached AP or BSSID of detected AP, Civic address and/or geospatial location information (NOTE 1, NOTE 5, NOTE 6).	UE/N5CW device local IP address (NOTE 2). In the case of WLAN access, BSSID of the attached AP or BSSID of detected AP, Civic address and/or geospatial location information (NOTE 1, NOTE 5, NOTE 6).	Null
N3IWF Side for Untrusted non- 3GPP Access; TNGF Side for trusted non-3GPP Access; TWIF Side for trusted WLAN Access; W-AGF Side for wireline Access	UE local IP address and optionally UDP or TCP source port (NOTE 2)	UE/N5CW device local IP address and optionally UDP or TCP source port (NOTE 2), TNAP/TWAP Id (NOTE 2)	HFC node ID for 5G-CRG in TS 23.316 [21] clause 10.1; GLI for 5G-BRG in TS 23.316 [21] clause 10.1.
AMF Side	UE local IP address and optionally UDP or TCP source port (NOTE 3). Last known 3GPP access User Location Info (NOTE 4).	UE/N5CW device local IP address and optionally UDP or TCP source port (NOTE 2, NOTE 3). Last known 3GPP access User Location Info (NOTE 4). TNAP/TWAP Id (NOTE 2)	HFC node ID for 5G-CRG in TS 23.316 [21] clause 10.1; GLI for 5G-BRG in TS 23.316 [21] clause 10.1
<p>NOTE 1: In the case of WLAN access, the UE may retrieve its location from a WLAN AP, prior or after association with the AP, requesting the Civic Location ANQP element, the Geospatial Location ANQP element or both as specified in IEEE Std 802.11-2012, using ANQP procedures described in HS2.0 Rel-12 specification.</p> <p>NOTE 2: More details can refer to TS 23.501 [18] clause 5.6.2.</p> <p>NOTE 3: This location information can be provided by location change event, more details can refer to TS 23.502 [19] clause 5.2.2.3.1.</p> <p>NOTE 4: This location information is also named as Last known Cell-Id, more details can refer to TS 23.501 [18] clause 5.6.2.</p> <p>NOTE 5: Geospatial location information can be obtained if UE (e.g. laptop) has installed GNSS receiver, i.e. GPS.</p> <p>NOTE 6: Some Applications (e.g. Google Map) may map the WiFi AP's BSSID with the geospatial locations obtain through GPS when the UE switch on the GPS and WiFi simultaneously. When another UE detect the same AP, the Application will send the geospatial locations to the UE. Thus the UE obtain the geospatial locations even without switch on the GPS. If the Application map the geospatial locations to civic address, the UE can also obtain the civic address.</p>			

If the UE registered to 3GPP access and non-3GPP access simultaneously, following information can be regarded as UE location information:

- All location information when the UE only registered to non-3GPP access,
- All location information when the UE only registered to 3GPP access, more details can refer to TS 36.305 [7].

5.3.2 Access Type Selection for LCS Service

The positioning of a UE can be performed via either 3GPP access network or non-3GPP access network.

For a MT-LR Location Service request, in order to select the positioning access type, the GMLC uses information retrieved from the UDM and optionally serving AMFs, e.g. access type, its serving AMF identity(ies), and UE connectivity state of this access, if available, and locally configured operator policy as follows:

- If only one AMF identity is provided by the UDM, the GMLC selects this AMF for UE positioning.

- When the UE is concurrently served by multiple PLMNs respectively for 3GPP access and non-3GPP access, multiple AMF identities with corresponding access types may be provided by the UDM, and the GMLC selects one access type and its associated AMF, which may be based on access type and its AMF, UE connectivity state per access type information, if this is retrieved from UDM or AMFs, PLMN identity, and/or locally configured operator policy. If the location estimation result provided by this AMF cannot fulfil the QoS requirements, the GMLC may reselect another access type and its associated AMF from the candidate list provided by the UDM to perform positioning.

When AMF receives a MT-LR Location Service request, the AMF shall provide to the LMF UE connectivity state per access type as well as the QoS requirement that are received from the GMLC.

When AMF receives the event report from the UE for a periodic or triggered MT-LR Location Service, the AMF may select a LMF or use the LMF indicated by the UE as described in clause 6.4 and clause 6.3.1 and may provide the UE connectivity state per access type to the LMF.

The LMF determines the positioning access type and positioning method based on the QoS requirement, UE/network positioning capability, and UE connectivity state per access type received from the AMF and the locally configured operator policy.

5.4 UE LCS privacy

5.4.1 General

An LCS client or AF may or may not be authorised to retrieve the UE location, e.g. for commercial use. UE LCS privacy is a feature which allows a UE and/or AF to control which LCS clients and AFs are and are not allowed access to UE location information. UE LCS privacy can be supported via subscription and via UE LCS privacy profile handling.

With subscription, privacy preferences for a UE are stored in a UE LCS privacy profile as part of UE subscription data in the UDM and queried from the UDM by another NF such as GMLC or NEF. The UDM may also store the UE privacy profile in the UDR. In this release of the specification, subscription of privacy preferences is restricted to the Call/Session unrelated Class as defined in clause 5.4.2.2.3 and the PLMN Operator Class as defined in clause 5.4.2.2.4.

With UE LCS privacy profile handling, the UE and/or AF can provide and update part of the UE privacy profile and provide it to the network as an update to the UDR. In this release of the specification, UE LCS privacy profile handling is restricted to the Location Privacy Indication as defined in clause 5.4.2.3.

The UE LCS privacy profile is used to indicate whether LCS requests from LCS clients and AFs are allowed or disallowed, together with the POI as defined in clause 5.4.4.

NOTE: In clause 5.4, even if the UE LCS privacy detail is only described for LCS client, the same detail is also applicable for AF, if no exception statement.

5.4.2 Content of UE LCS Privacy Profile

5.4.2.1 General

The UE LCS privacy profile shall include information related to classes of LCS client, referred to as "privacy classes", which are permitted, or conditionally permitted, to obtain location information for the UE. Privacy classes are defined in clause 9.5.3 of TS 23.271 [4], but not all classes defined in TS 23.271 [4] are supported in this specification. Privacy classes are supported as described below. The differences between the Privacy classes for 5GS and those for EPS are described in Annex A.

The UE LCS privacy profile also includes the Location Privacy Indication, as defined in clause 5.4.2.3, which can be provided and updated by the UE and/or AFs.

5.4.2.2 Privacy Classes

5.4.2.2.1 Universal Class

The universal class defined in clause 9.5.3.1 of TS 23.271 [4] is not supported in this specification.

5.4.2.2.2 Call/Session related Class

The call/session related class defined in clause 9.5.3.2 of TS 23.271 [4] is not supported in this specification.

5.4.2.2.3 Call/Session unrelated Class

The call/session unrelated class defined in clause 9.5.3.3 of TS 23.271 [4] is supported for a 5GC-MT-LR. The subscription options for the Call/Session unrelated Class may be assigned to an identified value added LCS Client, AF, value added LCS Client group or service type as described in clause 7.1 and comprise one of the following alternatives:

- positioning allowed without notifying the UE user (default case);
- positioning allowed with notification to the UE user;
- positioning requires notification and verification by the UE user; positioning is allowed only if granted by the UE user or if there is no response to the notification;
- positioning requires notification and verification by the UE user; positioning is allowed only if granted by the UE user.

NOTE: LCS service types are defined in TS 22.071 [2] and numeric values for LCS service types are listed in clause 17.7.8 of TS 29.002 [29].

A default subscription as described in TS 23.271 [4] clause 9.5.3.3 is included in the UE LCS privacy profile for any value added LCS client or AF not otherwise identified for the Call/Session unrelated Class and defines one of the following alternatives:

- positioning not allowed (default case);
- positioning allowed with notification to the UE user;
- positioning requires notification and verification by the UE user; positioning is allowed only if granted by the UE user or if there is no response to the notification;
- positioning requires notification and verification by the UE user; positioning is allowed only if granted by the UE user.

The subscription options for the Call/Session unrelated Class may further indicate additional information for each identified value added LCS client, for each identified service type and for the unidentified value added LCS clients as follows:

- A valid time period for positioning;
- A valid geographic area for positioning.

The UE LCS privacy profile may also indicate that any unidentified value added LCS client or an LCS Client associated with an identified service type shall provide a codeword in order to locate the UE, where the codeword is verified by either a GMLC or the UE. When verification by a GMLC is indicated, a list of one or more codewords is included as part of the UE LCS privacy profile.

5.4.2.2.4 PLMN Operator Class

The PLMN operator class defined in clause 9.5.3.4 of TS 23.271 [4] is supported.

5.4.2.3 Location Privacy Indication (LPI)

The Location Privacy Indication is not defined in TS 23.271 [4]. The Location Privacy Indication defines whether LCS requests for UE from any LCS clients are allowed or disallowed.

The LPI at least includes one of the following global settings (for all LCS clients and AFs):

- Location for UE is disallowed (location for UE not allowed to any LCS client except where POI applies).
- Location for UE is allowed (default setting, and LCS requests for UE from LCS clients are authorized based on their associated privacy classes as defined in clause 5.4.2.2).

NOTE: Additional LPI values may be supported for additional differentiation of location request types.

The LPI also allows the following optional settings:

- Valid time period for LPI, including start time and end time.

The LPI takes precedence on the subscribed privacy classes as defined in clause 5.4.2.2. The LPI allows a UE to override the location preference of the subscribed privacy classes. The usage of LPI is described in clause 6.1.2.

5.4.3 Provision of UE LCS privacy profile

A generation or change to the LPI in UE LCS privacy profile is determined by the UE and provided to the network using N1 NAS message. It may be updated by UE any time.

An authorized AF is allowed to provision the LPI in UE LCS privacy profile for specific UE(s) via NEF.

NOTE: The AF allowed to provision the UE LCS privacy profile is different from the AF sending location requests.

The LPI in UE LCS privacy profile may be provided or updated by the target UE during the 5GC-MT-LR and Deferred 5GC-MT-LR Procedure for Periodic, Triggered and UE Available Location Events. The updated profile is stored into the UDR by the UDM after the interaction with the AMF. The LPI in UE LCS privacy profile shall include an indication if location is allowed or disallowed and may include a valid time period for LPI as described in clause 5.4.2.3.

In addition, a notification is sent by the UDM in order to notify the subscribed consumer i.e. GMLC and NEF about the change of UE LCS privacy profile:

- Target UE identity (one or both of GPSI and SUPI);
- Updated UE LCS privacy profile.

5.4.4 Privacy Override Indicator (POI)

The POI is used to determine whether the UE LCS privacy profile of the subscriber to be positioned shall be overridden by the request for location services. The POI is applicable only to regulatory services. The assignment of a POI value with an "override" or "not override" value in the LCS client profile (see clause 7.2.1) is done during the LCS client provisioning (out of scope of this specification). The type of LCS client requesting location information (i.e. emergency, law-enforcement etc.) shall determine the value of the POI assigned to the LCS client profile.

5.4.5 LCS service authorization for an Immediate UE Location

UDM provides the UE LCS privacy profile to NEF and GMLC, if the information is available.

For a 5GC_MT_LR request for immediate location, the GMLC in the HPLMN, or the HGMLC when the UE is roaming, determines whether the LCS client or NF is authorized to retrieve UE location, based on the UE privacy profile.

NOTE 1: The UE LCS privacy profiles are not sent to the VGMLC.

Authorization is determined by first verifying whether the location request is allowed according to the Location Privacy Indication (LPI) defined in clause 5.4.2.3. If the location request is not allowed, an error response is returned to the LCS

client, AF, or NF. If the location request is allowed according to the LPI, authorization is next verified according to the Call/Session unrelated Class for an LCS Client or AF or according to the PLMN Operator Class for an NF.

For the Call/Session unrelated Class client types where POI does not apply, the HGMLC determines one of the following indications to be included in the location request forwarded to the serving AMF, or VGMLC in the case of roaming:

- Location allowed without notification;
- Location allowed with notification;
- Location with notification and privacy verification; location allowed if no response;
- Location with notification and privacy verification; location restricted if no response.

For PLMN Operator Class client types that are permitted to receive UE location information or where POI applies, a "location allowed without notification" is included.

For a Call/Session unrelated Class client type, which a geographic area restriction was included in the UE LCS privacy profile, the (H)GMLC performs an initial location by including a "location allowed without notification" indication in the location request sent to the VGMLC or AMF. The (H)GMLC then determines, based on the obtained location, whether location of the UE is allowed. If location of the UE is allowed subject to notification or verification, the (H)GMLC initiates a second location request to the VGMLC or serving AMF for the purpose of notification and/or verification only and includes one of the following indications in the second location request forwarded to the serving AMF, or VGMLC in the case of roaming:

- Notification only
- Notification and privacy verification only

When "Notification and privacy verification only" is included, the serving AMF shall report the result of privacy verification back to the (H)GMLC (i.e. location allowed, location not allowed or timeout on a response) and the (H)GMLC shall determine whether or not to return the location received for the first request back to the LCS client based or AF on this result.

For a direct NEF query to a serving AMF, or for an NEF query via the UDM, if GMLC is not involved, the NEF determines whether the AF is authorized to retrieve UE location, based on the UE LCS privacy profile.

NOTE 2: Notification and verification are not supported for a direct NEF query to a serving AMF, or for an NEF query via the UDM. Consequently, when notification or verification are required, or may be required based on a geographic area restriction, an NEF shall forward a location request to a GMLC or return an error indication to the requesting AF.

5.4.6 LCS service authorization for a Deferred UE Location

Support of UE LCS privacy for a deferred UE location is the same as that described in clause 5.4.5 for an immediate UE location with the differences and qualifications described in this clause.

An (H)GMLC or NEF shall subscribe to notification of a change in the UE LCS privacy profile from the UDM at the start of a deferred 5GC-MT-LR procedure and shall verify UE privacy both at the start of the deferred 5GC-MT-LR procedure and for each location result returned to an LCS client or AF based on the most recent UE LCS privacy profile received from the UDM.

If the UE LCS privacy profile indicates notification or verification of a location request is required for a particular value added LCS client, the (H)GMLC indicates this in the initial location request sent to the serving AMF and the serving AMF notifies the UE or verifies the location request with the UE, as for an immediate location request, when the UE first becomes reachable. The serving AMF also indicates the type of deferred location request in the NAS Location Notification Invoke Request sent to the UE. However, the location notification or verification is not repeated for each UE location in the case of a periodic or triggered 5GC-MT-LR.

For a value added LCS client, AF, value added LCS client group or LCS service type, for which a geographic area restriction was included, the (H)GMLC includes any request for notification or verification of the location request in the initial location request sent to the serving AMF. The (H)GMLC then determines whether a location result can be returned to the LCS client or AF based on whether the location result is or is not restricted by the geographic area

restriction. If the location result is allowed by the geographic area restriction, the (H)GMLC does not perform a second location request to the serving AMF for the purpose of notification and/or verification only. If the location result is not allowed by the geographic area restriction, the (H)GMLC discards the location result without notifying the LCS client or AF.

5.5 Location service exposure

Location service can be exposed to the authorized control plane NF or the LCS client to obtain the UE location to enable their application and services using the MT-LR procedure. For the location service exposed to the AF which is not allowed to directly interact with the GMLC or AMF, CAPIF API may be used between NEF and the AF as described in clause 6.2.5.1 of TS 23.501 [18].

For location service exposure, there are two types of location service requests as defined in clause 4.1a.4 and clause 4.1a.5:

- Location Immediate Request (LIR); and
- Location Deferred Request (LDR).

The following attributes may be included in the location service requests:

- Target UE identity;
- LCS Client identity or AF ID;
- Service identity, if needed;
- Codeword, if needed;
- Type of Event definition, i.e. UE available, change of area, motion or periodic location, applicable to deferred location requests only;
- Definitions for change of area type deferred location requests. Following parameters may be defined, if needed;
 - a) Indication for event trigger, i.e. UE enters, leaves or is within requested target area;
 - b) Indication of either a single event report or multiple event reports;
 - c) Minimum time interval between area event reports, if multiple event reports are requested;
 - d) Indication of the requested location estimate; i.e. whether the location estimate of the target UE should be contained in the change of area event report;
 - e) Duration of event reporting;
 - f) Maximum time interval between reports;
 - g) Maximum sampling time for event detection;
- Definitions for motion type deferred location requests. Following parameters may be defined, if needed;
 - a) Linear distance threshold;
 - b) Indication of either a single event report or multiple event reports;
 - c) Minimum time interval between motion event reports, if multiple event reports are requested;
 - d) Indication of the requested location estimate; i.e. whether the location estimate of the target UE should be contained in the motion event report;
 - e) Duration of event reporting;
 - e) Maximum time interval between reports;
 - f) Maximum sampling time for event detection;

- Definitions for periodic location type deferred location requests. Following parameters may be defined, if needed:
 - a) Time interval between successive location reports;
 - b) Total number of reports;
- Start time, stop time (i.e. specifying the validity time of LCS request), if needed for LCS Client e.g. using the OMA MLP protocol;
- Interval, applicable to periodical requests only;
- Requested LCS Quality of Service information, if needed, i.e. accuracy, response time and LCS QoS Class;
- Requested type of location, i.e. "current location", "current or last known location" or "initial location" applicable to LIR only (current location is only available for LDR);
- Velocity of the UE, if needed;
- Priority, if needed;
- Service coverage (i.e. E.164 country codes for geographic areas, ITU-T Recommendation E.164 [23]), if needed;
- Requested maximum age of location, if needed;
- Local coordinate reference system, if needed for LCS Client e.g. using the OMA MLP protocol;
- Target area, i.e. geographical area expressed as one of the following format, if needed:
 - a) a shape defined in TS 23.032 [8];
 - b) local coordinate system for LCS Client e.g. using the OMA MLP protocol;
 - c) E.164 country code for a geographic area [23] for LCS Client e.g. using the OMA MLP protocol;
 - d) PLMN identity for LCS Client e.g. using the OMA MLP protocol;
 - e) geopolitical name of the area (e.g. London) for LCS Client e.g. using the OMA MLP protocol;
- Response Method, if needed for LCS Client e.g. using the OMA MLP protocol.

The following attributes may be included in the location service response:

- Location indication of UE in geographical coordinates expressed as a shape as defined in TS 23.032 [8] or for LCS Client e.g. using the OMA MLP protocol, local coordinate system;
- Velocity of the UE as defined in TS 23.032 [8], if requested and if available;
- The information about the positioning method used to obtain the location estimate of the UE, if it is available at the LCS server and if needed;
- Time stamp of location estimate;
- Indication when UE enters, is within or leaves the Geographical area, if needed;
- Acknowledgement for a deferred location request, if needed.
- Request id, if needed.
- Indication that the requested QoS was not met, if needed, only applicable if the request was for best effort class
- Indication of a periodic event.
- Indication of a motion event.
- Indication that a deferred location request has been activated in a UE.

- Indication of expiration of the maximum reporting interval for the area event or motion event for LCS Client e.g. using the OMA MLP protocol.

In addition, the information attributes of the location service request may be used also in the location service response.

For a LCS client in the core network, the LCS service request is sent to GMLC using Le interface.

For an AF not allowed to directly interact with the GMLC or AMF, the LCS service request is sent to NEF using the service based interface.

For an internal control plane NF, the LCS service request is sent to AMF or GMLC using the service based interface.

NOTE: For regulatory services, any control plane NF can be LCS client.

To support location service exposure through NEF, when NEF receives a LCS service request, it determines based on the location accuracy of the QoS requirement, e.g. lower or higher than cell-ID level, on whether to invoke the GMLC service or the AMF service for the LCS service request.

5.6 LCS Charging

Charging Information for LCS service is collected at GMLC and AMF. For roaming case, the Charging Information shall be collected in both home PLMN and visited PLMN for inter-operator charging purpose.

Charging mechanism for LCS service and the Charging Information collected at GMLC and at AMF are defined in TS 32.271 [30] and TS 32.298 [31].

5.7 Support of Concurrent Location Requests

5.7.1 General

Concurrent Location Requests occur when any entity (e.g. UE, AMF, LMF, GMLC, NEF):

- Case A: receives/initiates multiple LCS requests (e.g. 5GC-MT LR, 5GC-MO LR, 5GC-NI LR) for the location estimate of the same target UE within a time period; or
- Case B: receives/initiates one or more new LCS request(s) (e.g. 5GC-MT LR, 5GC-MO LR, 5GC-NI LR) for the location estimate of the same target UE during the location session to support the old LCS request(s).

In either case, if allowed by the QoS requirements and privacy settings, the entity may combine the concurrent location requests by fully executing one of the requests and using the ensuing location estimate result(s) to satisfy the other request(s) without fully executing the latter. When concurrent location requests are supported, each entity needs to ensure it correlates each location/position response with the associated request and different concurrent location requests shall be treated separately without any dependency on one another by any entity.

NOTE 1: Combining of location requests is not allowed for a deferred 5GC-MT-LR for periodic or triggered location for privacy reasons (e.g. a target UE would not be aware that location event reports were being sent to multiple AFs and/or external LCS clients).

NOTE 2: An entity (e.g. AMF, GMLC, NEF) may cache location information obtained for one location request and use this information to support later location requests for "current or last known location". This is not considered to be a case of concurrent location requests.

If the entity, either itself or in association with another entity, cannot support concurrent location requests or it can only support up to a certain number of concurrent location requests, it can reject or defer a new concurrent request or cancel one or more existing requests. For Case B, it can also allow the new location request to proceed concurrently with and separately from the previous requests.

LCS Client/AF priority and any other relevant priority information (e.g. UE subscription preferences) should be considered when rejecting or deferring a concurrent request or when cancelling one or more existing requests. In particular, location requests associated with emergency services or lawful interception clients should be given priority over other location requests.

5.7.2 Combining location requests by an H-GMLC or NEF

An H-GMLC or NEF may combine concurrent location requests (e.g. 5GC-MT LR, 5GC-MO LR, 5GC-NI LR) for the same target UE by executing only one request and using the ensuing location estimate result(s) to satisfy the other request(s). The conditions for this are as follows:

- the H-GMLC must be able to fully resolve privacy requirements for the other location request(s) without requiring notification or verification by the UE (though notification only as in steps 17-23 of clause 6.1.2 could still be used in the case of location dependent privacy); and
- the QoS for the other request(s) should be less strict than the QoS for the executed location request.

An H-GMLC may also combine concurrent location requests in the case of a bulk location request for a group of UEs as described in clause 6.8. In this case, location information for any UE in the group may be obtained from location information obtained from another concurrent location request for the same UE.

5.7.3 Combining location requests by a V-GMLC

A V GMLC may combine concurrent 5GC-MT LR and 5GC-MO-LR related location requests for the same target UE provided it is clear and unambiguous for any 5GC-MT LR that will not be fully executed (e.g. from the contents of any location request received from the H GMLC) that no outstanding privacy related actions are required for the UE (e.g. no privacy notification and/or privacy verification interaction with the UE). QoS requirements must also be satisfied for the non-executed location requests.

5.7.4 Combining location requests by an AMF

An AMF may combine concurrent 5GC-MT LR, 5GC-MO LR and 5GC-NI LR location requests once any needed privacy related actions (e.g. UE notification and verification) have been performed for each 5GC-MT LR. (i.e. AMF may decide to not execute multiple positioning procedures for the concurrent location requests) QoS requirements must also be satisfied for the non-executed location requests.

5.7.5 Combining location requests by an LMF

An LMF may combine concurrent location requests for the same target UE provided QoS requirements can be satisfied for the non-executed location requests.

5.7.6 Combining location requests by a UE

A UE may combine concurrent location requests provided QoS requirements can be satisfied and provided any positioning procedures with an LMF remain supported according to the positioning protocol.

5.8 Interworking with the IMS

When the location service request is initiated by the LCS Client / AF for the location estimation of a target UE in an IMS session, a SIP-URI or a TEL-URL maybe included in the request to identify the target UE. In that case, the H-GMLC of the UE shall be able to convert the SIP-URI/TEL-URL into SUPI of the target UE.

NOTE 1: The H-GMLC may query IMS-HSS or UDM to retrieve the SUPI of the target UE based on its SIP-URI/TEL-URL.

NOTE 2: If multiple SUPIs are resolved for the SIP-URI/TEL-URL, the H-GMLC behaviour is out of scope of this specification.

6 Location Service Procedures

6.1 5GC-MT-LR Procedure

6.1.1 5GC-MT-LR procedure for the regulatory location service

Figure 6.1.1-1 illustrates the general network positioning for the LCS clients external to the PLMN for the regulatory location service for non-roaming scenario. In this scenario, it is assumed that the target UE is identified using an SUPI or GPSI.

This procedure is applicable to a request from an LCS client for a current location of the target UE, and it is assumed that the LCS client is authorised to use the location service and no privacy verification is required.

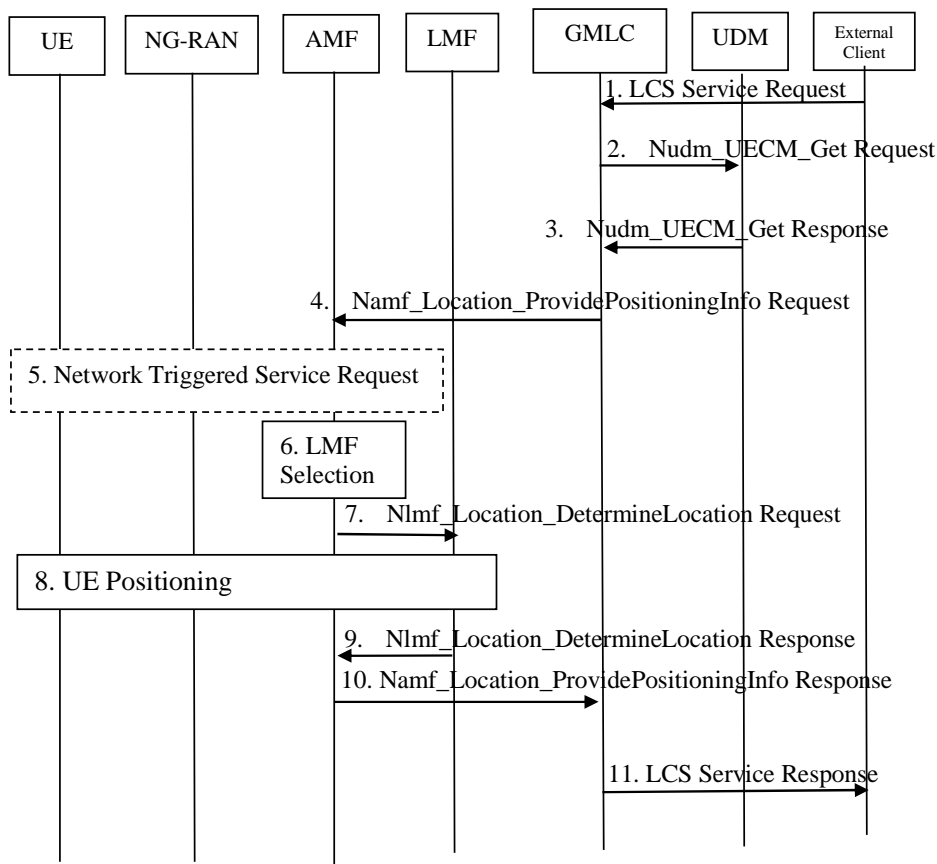


Figure 6.1.1-1: 5GC-MT-LR procedure for the regulatory location service

1. The external location services client sends a request to the GMLC for a location for the target UE identified by an GPSI or an SUPI. The request may include the required QoS and Supported GAD shapes. If location is required for more than one UE, the steps following below may be repeated and in that case the GMLC shall verify whether the number of Target UEs in the LCS request is equal to or less than the Maximum Target UE Number of the LCS client. If Maximum Target UE Number is exceeded, the GMLC shall reject the LCS request, the step 2-10 are skipped, and then GMLC respond to the client with proper error cause in the step 11.
2. The GMLC invokes a Nudm_UECM_Get service operation towards the home UDM of the target UE to be located with the GPSI or SUPI of this UE.
3. The UDM returns the network addresses of the current serving AMF.

NOTE: For backward compatibility, the GMLC can use a Nudm_SDM_Get service operation to retrieve the SUPI of the target UE from a Rel-15 UDM as defined in 23.502 [19] clause 5.2.3.3.2.

4. The GMLC invokes the `Namf_Location_ProvidePositioningInfo` service operation towards the AMF to request the current location of the UE. The service operation includes the SUPI, and client type and may include the required QoS and Supported GAD shapes.
5. If the UE is in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.
6. The AMF selects an LMF based on the available information as defined in clause 5.1 or based on AMF local configuration. The LMF selection takes the 5G-AN currently serving the UE into account. The selection may use a NRF query.
7. The AMF invokes the `Nlmf_Location_DetermineLocation` service operation towards the LMF to request the current location of the UE. The service operation includes a LCS Correlation identifier, the serving cell identity of the Primary Cell in the Master RAN node and the Primary Cell in the Secondary RAN node when available based on Dual Connectivity scenarios, and the client type and may include an indication if UE supports LPP, the required QoS and Supported GAD shapes. If any of the procedures in clause 6.11.1 or clause 6.11.2 are used the service operation includes the AMF identity.
8. The LMF performs one or more of the positioning procedures described in clauses 6.11.1, 6.11.2 and 6.11.3. During this step the LMF may use the `Namf_Communication_N1N2MessageTransfer` service operation to request the transfer of a Positioning related N1 message to the UE or the transfer of a Network Positioning message to the serving NG-RAN node (gNB or NG-eNB) for the UE.
9. The LMF returns the `Nlmf_Location_DetermineLocation` Response towards the AMF to return the current location of the UE. The service operation includes the LCS Correlation identifier, the location estimate, its age and accuracy and may include information about the positioning method.
10. The AMF returns the `Namf_Location_ProvidePositioningInfo` Response towards the GMLC/LRF to return the current location of the UE. The service operation includes the location estimate, its age and accuracy and may include information about the positioning method.
11. The GMLC sends the location service response to the external location services client.

6.1.2 5GC-MT-LR Procedure for the commercial location service

Figure 6.1.2-1 illustrates the general network positioning requested by the LCS clients or the AF. In this scenario, it is assumed that the target UE may be identified using an SUPI or GPSI. This procedure is applicable to a request from an LCS client or AF for a current location of the target UE, and it is assumed that

- Privacy verification may be required for the location service request;
- The LCS client or the AF needs to be authorised to use the location service.

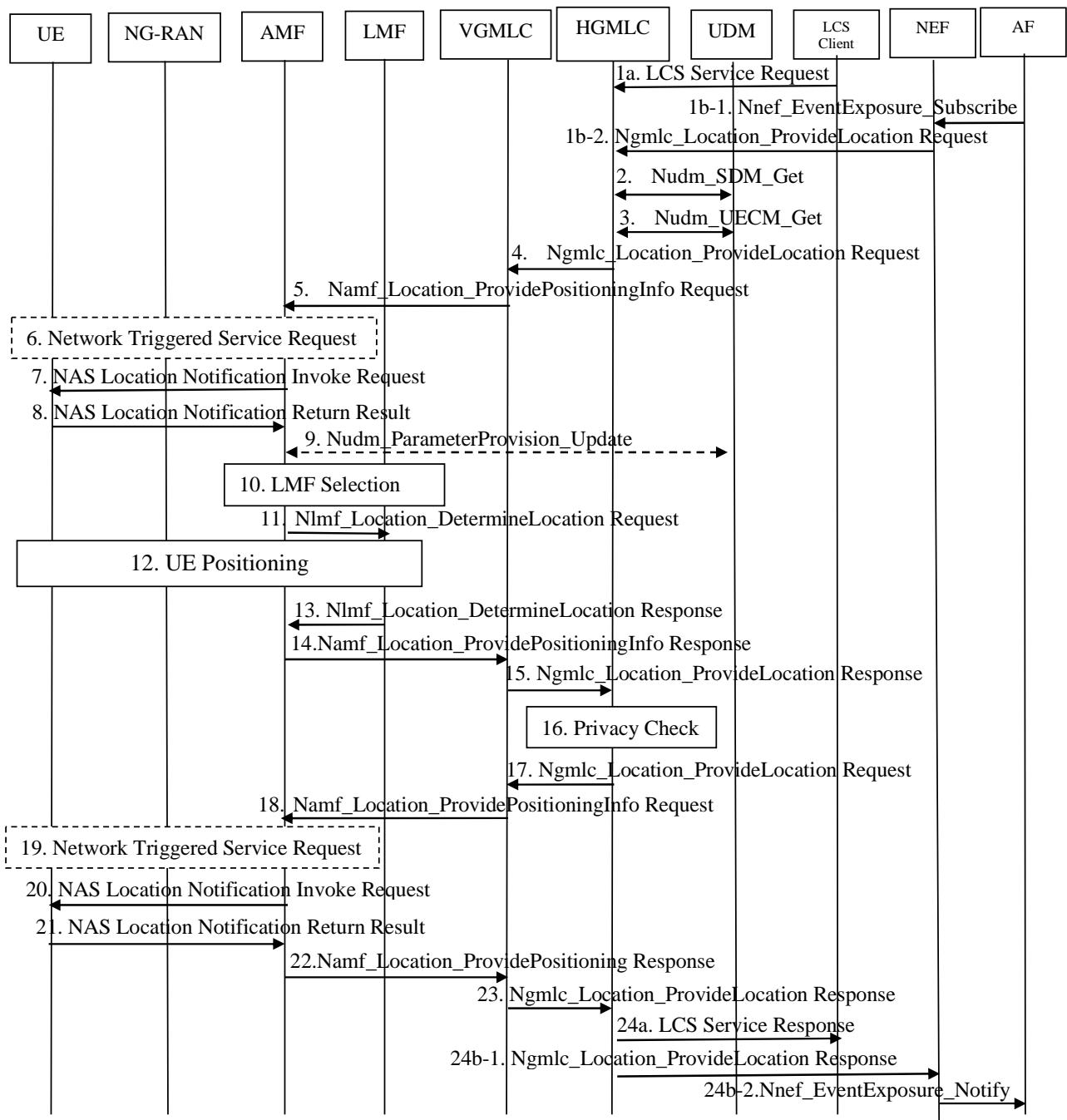


Figure 6.1.2-1: 5GC-MT-LR Procedure for the commercial location services

1. The LCS Client or the AF (via NEF) sends a request to the (H)GMLC for a location and optionally a velocity for the target UE which may be identified by an GPSI or an SUPI. The request may include the required QoS, supported GAD shapes and other attributes. (H)GMLC (for 1a) or NEF (for 1b) authorizes the LCS Client or the AF for the usage of the LCS service. If the authorization fails, step 2-23 are skipped and (H)GMLC (for 1a) or NEF (for 1b) responds to the LCS Client or the AF the failure of the service authorization in step 24. In some cases, the (H)GMLC derives the GPSI or SUPI of the target UE and possibly the QoS from either subscription data or other data supplied by the LCS Client or AF.

The LCS request may carry also the Service Identity (see TS 22.071 [2]) and the Codeword and the service coverage information. The (H)GMLC may verify that the Service Identity received in the LCS request matches one of the service identities allowed for the LCS client or AF. If the service identity does not match one of the service identities for the LCS client or AF, the (H)GMLC shall reject the LCS request. Otherwise, the (H)GMLC can map the received service identity in a corresponding service type.

If the LCS service request contains the pseudonym of the target UE and the (H)GMLC cannot resolve the PMD address from the pseudonym, the (H)GMLC itself determines the verinym (GPSI or SUPI) of the target UE. If the (H)GMLC can resolve the address of PMD from the pseudonym, the HGMLC requests the verinym from its associated PMD. If (H)GMLC is not able to obtain the verinym of the target UE, the (H)GMLC shall cancel the location request.

If the requested type of location is "current or last known location" and the requested maximum age of location information is available, the (H)GMLC verifies whether it stores the previously obtained location estimate of the target UE. If the HGMLC stores the location estimate and the location estimate satisfies the requested accuracy and the requested maximum age of location, the (H)GMLC checks the result of the privacy check at step 2. If the result of the privacy check for call/session unrelated class is "Location allowed without notification" then steps 3-23 may be skipped.

1b-1 AF sends the Nnef_EventExposure_Subscribe to the NEF.

1b-2 The NEF identifies based on the QoS attribute received from the location request that higher than cell-ID level location accuracy is required and invokes the Ngmlc_Location_ProvideLocation_Request service operation to the (H)GMLC, which contains the attributes received from the AF request. The NEF may also invoke the Ngmlc_Location_ProvideLocation_Request service operation to the (H)GMLC for lower than cell-ID location accuracy as an implementation option. NEF derives the LCS client type of the AF, and provides it to H-GMLC.

If step 1a is received, H-GMLC derives the LCS client type of the LCS client.

If location is required for more than one UE, the steps following below may be repeated and in that case the NEF or HGMLC receiving location request, shall verify whether the number of Target UEs in the Nnef_EventExposure_Subscribe or LCS request is equal to or less than the Maximum Target UE Number of the LCS client. If Maximum Target UE Number is exceeded, the NEF or HGMLC shall reject the Nnef_EventExposure_Subscribe or LCS request, the steps 2-23 are skipped, and then GMLC respond to the client with proper error cause in the step 24.

NOTE 1: If cell-ID level or lower than cell-ID level location accuracy is required in the location request, the NEF may invoke an Namf_EventExposure_Subscribe service operation to subscribe location event reporting from the AMF for the target UE as further described in clause 6.5.

2. The (H)GMLC invokes a Nudm_SDM_Get service operation towards the UDM of the target UE to get the privacy settings of the UE identified by its GPSI or SUPI. The UDM returns the target UE Privacy setting and the SUPI of the UE. The (H)GMLC checks the UE LCS privacy profile. If the target UE is not allowed to be located, steps 3-23 are skipped.
3. The (H)GMLC invokes a Nudm_UECM_Get service operation towards the UDM of the target UE with SUPI of this UE. The UDM returns the network addresses of the current serving AMF and additionally the address of a VGMLC (for roaming case). If the location request is an immediate location request, the (H)GMLC checks the country codes of the serving node addresses. If the (H)GMLC finds the current AMF is out of the service coverage of the (H)GMLC, the (H)GMLC returns an appropriate error message to the LCS client or AF (via NEF).

NOTE 2: The UDM is aware of the serving AMF address at UE registration on an AMF as defined in clause 4.2.2.2.2 of TS 23.502 [19]. The UDM is aware of a serving VGMLC address at UE registration on an AMF as defined in clause 4.2.2.2.2 of TS 23.502 [19].

NOTE 3: The HGMLC can also query the HSS of the target UE for a serving MME address as described in clause 9.1.1 of TS 23.271 [4]. The EPC-MT-LR procedure described in clause 9.1.15 of TS 23.271 [4], excluding the UE availability event, may then be performed instead of steps 4-23, e.g. if the HSS returns an MME address but the UDM does not return an AMF address.

4. For a non-roaming case, this step is skipped. In the case of roaming, the HGMLC may receive an address of a VGMLC (together with the network address of the current serving AMF) from the UDM in step 3, otherwise, the HGMLC may use the NRF service in the HPLMN to select an available VGMLC in the VPLMN, based on the VPLMN identification contained in the AMF address received in step 3. The HGMLC then sends the location request to the VGMLC by invoking the Ngmlc_Location_ProvideLocation service operation towards the VGMLC. In the cases when the HGMLC did not receive the address of the VGMLC, or when the VGMLC address is the same as the HGMLC address, or when both PLMN operators agree, the HGMLC sends the location service request message to the serving AMF. In this case, step 4 is skipped. If the result of privacy check

indicates that the verification based on current location is needed, the HGMLC shall send a location request to the VGMLC (in the case of roaming) or to the AMF (in the case of non-roaming) indicating "positioning allowed without notification" and VGMLC shall invoke an Namf_Location_ProvidePositioningInfo Request service operation towards the AMF at step 5. H-GMLC also provides the LCS client type of AF, if received in step 41b-2, or LCS client type of LCS client and other attributes to be sent to AMF in step 5.

5. In the case of roaming, the VGMLC first authorizes that the location request is allowed from this HGMLC, PLMN or from this country. If not, an error response is returned. The (H)GMLC or VGMLC invokes the Namf_Location_ProvidePositioningInfo service operation towards the AMF to request the current location of the UE. The service operation includes the SUPI, the client type and may include the required LCS QoS, supported GAD shapes, service type and other attributes as received or determined in step 1.

NOTE 4: The location request forwarded at step 4 and step 5 may also carry the result of the privacy check in step 2 which may include a codeword provided by the LCS Client or AF and an indication of a privacy related action as described in clause 5.4.

6. If the UE is in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.

If signalling connection establishment fails, step 7-13 are skipped and the AMF answers to the GMLC in step 14 with the last known location of the UE (i.e. Cell ID) together with the age of this location.

7. If the indicator of privacy check related action indicates that the UE must either be notified or notified with privacy verification and if the UE supports LCS notification (according to the UE capability information), a notification invoke message is sent to the target UE, indicating the identity of the LCS client and the service type (if that is both supported and available) and whether privacy verification is required.
8. The target UE notifies the UE user of the location request and, if privacy verification was requested, waits for the user to grant or withhold permission. The UE then returns a notification result to the AMF indicating, if privacy verification was requested, whether permission is granted or denied for the current LCS request. If the UE user does not respond after a predetermined time period, the AMF shall infer a "no response" condition. The AMF shall return an error response in step 14 and if roaming VGMLC in step 15 to the HGMLC if privacy verification was requested and either the UE user denies permission or there is no response with the indication received from the (H)GMLC indicating barring of the location request and steps 10-13 are skipped.

The notification result may also indicate the Location Privacy Indication setting for subsequent LCS requests; i.e. whether subsequent LCS requests, if generated, will be allowed or disallowed by the UE. The Location Privacy Indication may also indicate a time for disallowing the subsequent LCS requests.

9. The AMF invokes the Nudm_ParameterProvision_Update (LCS privacy) service operation to store in the UDM the Location Privacy Indication information received from the UE. The UDM may then store the updated UE privacy setting information into the UDR as the "LCS privacy" Data Subset of the Subscription Data.

10-13. Step 10-13 are the same as steps 6-9 defined in clause 6.1.1 with the addition that service type may be indicated towards the LMF.

14. The AMF returns the Namf_Location_ProvidePositioningInfo Response towards the (V)GMLC (or HGMLC for roaming when the NL3 reference point is not supported) to return the current location of the UE. The service operation includes the location estimate, its age and accuracy and may include information about the positioning method.

15. In the case of roaming, the VGMLC forwards the location estimation of the target UE, its age, its accuracy and optionally the information about the positioning method received at step 14 to the HGMLC. For non-roaming scenario, this step is skipped.

16. If the privacy check in step 2 indicates that further privacy checks are needed, the (H)GMLC shall perform an additional privacy check in order to decide whether the (H)GMLC can forward the location information to the LCS client or AF or send a notification if the result of the privacy check requires the notification and verification based on current location. One example when this additional privacy check is needed is when the target UE user has defined different privacy settings for different geographical locations. When an additional privacy check is not needed, the (H)GMLC skips steps 17-23.

17. If the result of privacy checks in step 16 indicates that the notification (and verification) based on current location is needed, and in the case of roaming, the (H)GMLC shall send a location request to the VGMLC with location type indicating "notification only".
18. The (H)GMLC or VGMLC invokes the Namf_Location_ProvidePositioningInfo service operation towards the AMF to request notification (and verification) based on current location.
19. If the UE is in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.
20. If the indicator of privacy check related action indicates that the UE must either be notified or notified with privacy verification and if the UE supports LCS notification, the AMF sends a notification invoke message to the target UE, indicating the identity of the LCS client and the service type (if that is both supported and available) and whether privacy verification is required.
21. Step 21 is the same as step 8.
22. The AMF returns the Namf_Location_ProvidePositioningInfo Response towards the (V)GMLC (or HGMLC for roaming when the NL3 reference point is not supported) with an indication of the result of notification and verification procedure performed in steps 20-21.
23. In the case of roaming, the VGMLC forwards an indication of the result of notification and verification procedure to the HGMLC. For non-roaming scenario, this step is skipped.
24. The (H)GMLC sends the location service response to the LCS Client or AF (via the NEF) if the target UE is allowed to be located by the LCS Client or AF. If the location request from the LCS Client contained the pseudonym and the (H)GMLC resolved the verinyim from the pseudonym in step 1, the (H)GMLC shall use the pseudonym of the target UE in the location response to the external LCS client. If the external LCS client or AF requires it, the (H)GMLC may first transform the universal location co-ordinates provided by the AMF into some local geographic system. The (H)GMLC may record charging information both for the LCS Client or AF and inter-network revenue charges from the AMF's network. The location service response from the (H)GMLC to the LCS Client or AF may contain the information about the positioning method used and the indication whether the obtained location estimate satisfies the requested accuracy or not. If in step 2, step 15, step 16 or step 23 the (H)GMLC identifies that the target UE is not allowed to be located by the LCS Client or AF, it rejects the LCS service request, and optionally indicate in the response the reason of the rejection, i.e. the target UE is not allowed to be located. If the LCS QoS Class is Assured and (H)GMLC detects that requested accuracy is not achieved, the (H)GMLC sends error response including failure cause.

6.2 5GC-MO-LR Procedure

Figure 6.2-1 illustrates the general network positioning requested by the UE to the serving PLMN for obtaining the location related information of itself or just assistance data.

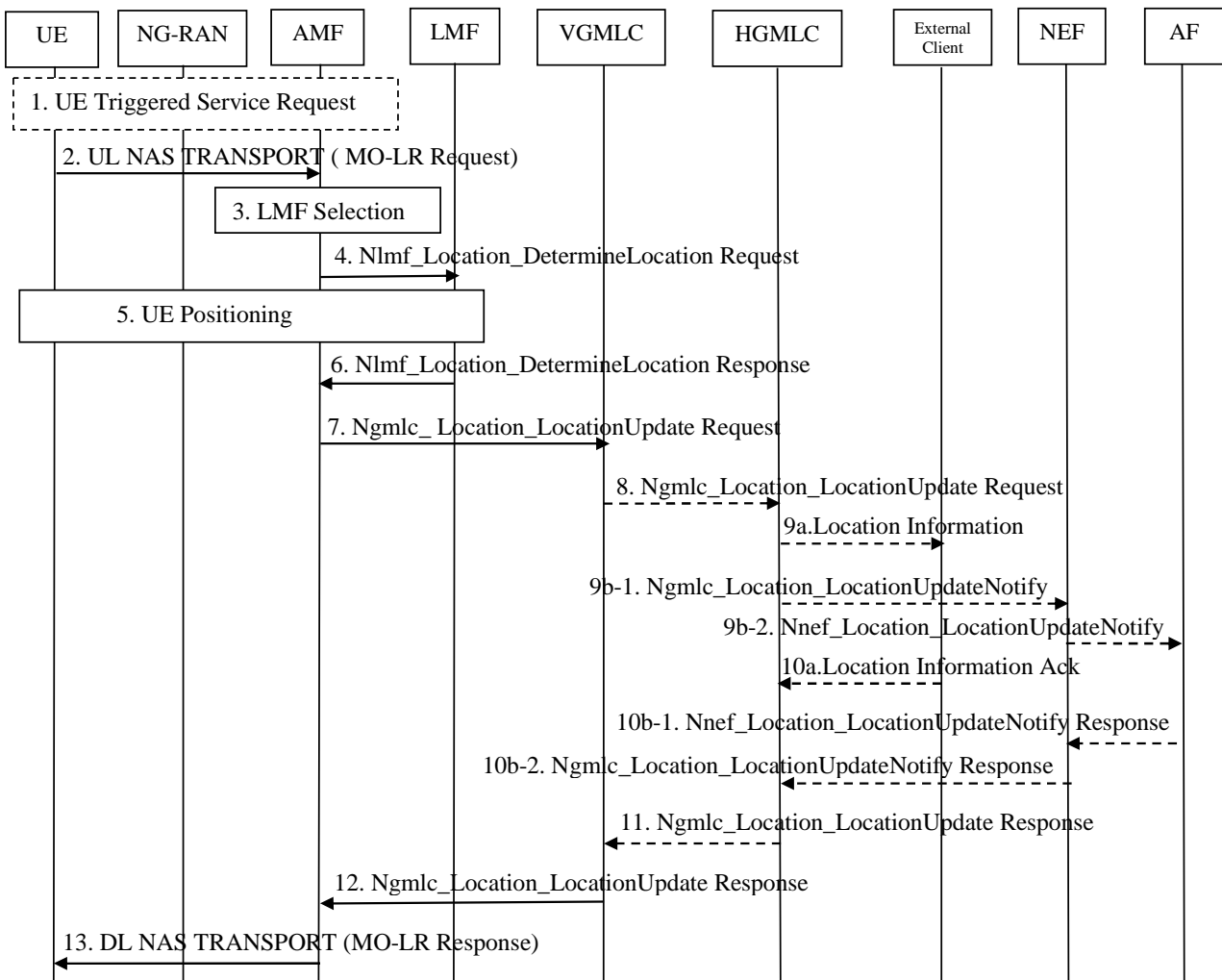


Figure 6.2-1: 5GC-MO-LR Procedure

- 1) If the UE is in CM-IDLE state, UE instigates the UE triggered Service Request as defined in clause 4.2.3.2 of TS 23.502 [19] in order to establish a signalling connection with the AMF.
- 2) The UE sends an MO-LR Request message included in a UL NAS TRANSPORT message. The MO-LR Request may optionally include an LPP positioning message. Different types of location services can be requested: location estimate of the UE, location estimate of the UE to be sent to an LCS client or AF, or location assistance data. If the UE is requesting its own location or that its own location be sent to an LCS client or AF, this message carries LCS requested QoS information (e.g. accuracy, response time, LCS QoS Class), the requested maximum age of location and the requested type of location (e.g. "current location", "current or last known location"). If the UE is requesting that its location be sent to an LCS client, the message shall include the identity of the LCS client or the AF, and may include the address of the GMLC through which the LCS client or AF (via NEF) should be accessed. In addition, a Service Identity indicates which MO-LR service of the LCS Client is requested by the UE may be included. The message also may include a pseudonym indicator to indicate a pseudonym should be assigned by the network and transferred to the LCS Client as the UE's identity. If the UE is instead requesting location assistance data, the embedded LPP message specifies the type of assistance data and the positioning method for which the assistance data applies.

For an LCS 5GC-MO-LR requesting location transfer to an LCS Client or AF, the AMF shall assign a GMLC address, i.e. VGMLC address, which is stored in the AMF. If a VGMLC address is not available, the AMF may reject the location request. The AMF verifies the subscription profile of the UE and decides if the requested service is allowed or not.

- 3) The AMF selects an LMF as described in clause 5.1.

- 4) The AMF invokes the Nlmf_Location_DetermineLocation service operation towards the LMF. The service operation includes an LCS Correlation identifier, the serving cell identity, the client type, an indication whether a location estimate, or location assistance data is requested and any embedded LPP message in the MO-LR Request. If the UE's location is requested, the service request may include an indication if UE supports LPP, the requested QoS and Supported GAD shapes. If location assistance data is requested, the embedded LPP message will convey the requested types of location assistance data. If any of the procedures in clause 6.11.1 or 6.11.2 are used the service operation includes the AMF identity. Once an AMF has selected an LMF it must continue to use that LMF for the duration of the session.
- 5) If the UE is requesting its own location, the actions described in clause 6.11 are performed. If the UE is instead requesting location assistance data, the LMF transfers this data to the UE as described in clause 6.11.1. The LMF determines the exact location assistance data to transfer according to the type of data specified by the UE, the UE location capabilities and the current cell.
- 6) When a location estimate best satisfying the requested QoS has been obtained or when the requested location assistance data has been transferred to the UE, the LMF returns the Nlmf_Location_DetermineLocation Response towards the AMF. The service operation includes the LCS Correlation identifier, the location estimate, if this was obtained, its age and accuracy and may include information about the positioning method.

If a location estimate was not successfully obtained, or if the requested location assistance data could not be transferred successfully to the UE, a failure cause is included in the service operation.

If the UE is requesting location assistance data, steps 7 to 12 are skipped.

- 7) If the location estimate was successfully obtained, the AMF invokes the Ngmlc_Location_LocationUpdate service operation towards to the VGMLC assigned in the step 2. The service operation carries the identity of the UE, the event causing the location estimate (5GC-MO-LR) and the location estimate, its age, obtained accuracy indication and the LCS QoS Class requested by the target UE. In addition, the service operation may include the pseudonym indicator, the identity of the LCS Client, AF ID, the GMLC address and the Service Identity specified by the UE, if available.
- 8) If the UE did not request transfer of its location to an LCS Client or AF in step 2, steps 8 to 11 are skipped. If the VGMLC is same NF instance as HGMLC this step is skipped. Otherwise VGMLC invokes the Ngmlc_Location_LocationUpdate service operation towards to the HGMLC (the VGMLC may query the UDM of the UE to obtain the address of the HGMLC) including the information received from the VGMLC.
- 9a) If the pseudonym indicator is included in the MO-LR Location Information, the HGMLC assigns a pseudonym to the UE. If the identified LCS Client is not accessible by the HGMLC, step 9a and step 10a are skipped. Otherwise the GMLC transfers the location information to the LCS client, carrying the identity or the pseudonym of the UE, the event causing the location estimate (5GC-MO-LR), the Service Identity, if available, and the location estimate and its age, in accordance with the LCS QoS Class requested by the target UE. If the UE requested LCS QoS class was Assured, GMLC sends the result to the LCS client only if the result has been indicated to fulfil the requested accuracy. If the UE requested LCS QoS class was Best Effort, GMLC sends whatever result it received to the LCS client with an appropriate indication if the requested accuracy was not met.
- 9b-1) If the AF ID is included in step 1, the HGMLC assigns the NEF address based on local configuration or via NRF and invokes Ngmlc_Location_LocationUpdateNotify service request towards the NEF, carrying the AF ID. The location information parameters sent within this service operation are same as the step 9a except that no pseudonym is included.
- 9b-2) If the identified AF is not accessible by the NEF, step 9b-2 and step 10b-1 are skipped. Otherwise, the NEF transfer the location information to the identified AF by invoking the Nnef_Location_LocationUpdateNotify service.
- 10a) If the LCS Client does not support MO-LR (for temporary or permanent reasons) or cannot handle the location estimate of the UE, e.g. the LCS Client does not know the Service Identity, or the UE does not register to the LCS Client, the LCS Client has no corresponding data of the UE, the LCS Client shall return the Location Information ack message to the HGMLC with a suitable error cause. Otherwise, the LCS Client handles the location estimate according to the Service Identity, sends the GMLC or the HGMLC the Location Information ack message signalling that the location estimate of the UE has been handled successfully.
- 10b-1) If the AF cannot handle the location estimate of the UE, e.g. the UE does not register to the AF, the AF has no corresponding data of the UE, the AF shall respond to the Nnef_Location_LocationUpdateNotify service

request with a suitable error cause. Otherwise, the AF handles the location estimate according to the Service Identity and respond to the Nnef_Location_LocationUpdateNotify service request indicating that the location estimate of the UE has been handled successfully.

10b-2) The NEF sends a Ngmlc_Location_LocationUpdateNotify service response towards the HGMLC with the outcome of the operation.

11) If the VGMLC is same NF instance as HGMLC this step is skipped. If the identified LCS Client or AF is not accessible, the HGMLC sends a Ngmlc_Location_LocationUpdate service response to VGMLC with an appropriate error cause. Otherwise, the response shall include an acknowledgement. The message shall specify whether the location estimate of the UE has been handled successfully by the identified LCS Client or AF, and if not, the corresponding error cause obtained in step 10. In addition, the HGMLC may record charging information both for the UE and inter-working revenues charges.

12) If the VGMLC receives the MO-LR Location Information Acknowledgement from the HGMLC, if the identified LCS Client or AF is not accessible, the VGMLC sends a Ngmlc_Location_LocationUpdate service response to AMF with an appropriate error cause. Otherwise, the response shall include an acknowledgement. The message shall specify whether the location estimate of the UE has been handled successfully by the identified LCS Client or AF, and if not, the corresponding error cause obtained in step 9 or 10. In addition, the VGMLC may record charging information both for the UE and inter-working revenue charges.

If the VGMLC receives Ngmlc_Location_LocationUpdate Request from the AMF and it is not required to send to any LCS Client or AF, the VGMLC may record charging information for the UE and response the Ngmlc_Location_LocationUpdate Request to the AMF.

13) The AMF sends an MO-LR Response message included in a DL NAS TRANSPORT message. If the UE is requesting its own location, the response carries any location estimate requested by the UE including the indication received from LMF whether the obtained location estimate satisfies the requested accuracy or not, or an indicator whether a location estimate was successfully transferred to the identified LCS client or AF. If the location estimate was successfully transferred to the identified LCS Client or AF, the MO-LR Response message shall specify whether the location estimate of the UE has been handled successfully by the identified LCS Client or AF, and if not, the corresponding error cause obtained in step 12. In addition, AMF may record charging information.

6.3 Deferred 5GC-MT-LR Procedure for Periodic, Triggered and UE Available Location Events

6.3.1 Initiation and Reporting of Location Events

Figure 6.3.1-1 summarizes the initiation and reporting of location events for a deferred 5GC-MT-LR procedure for Periodic, Triggered and UE Available Location Events. The procedure supports mobility of a UE within a VPLMN 5GCN and from a 5GCN to an EPC.

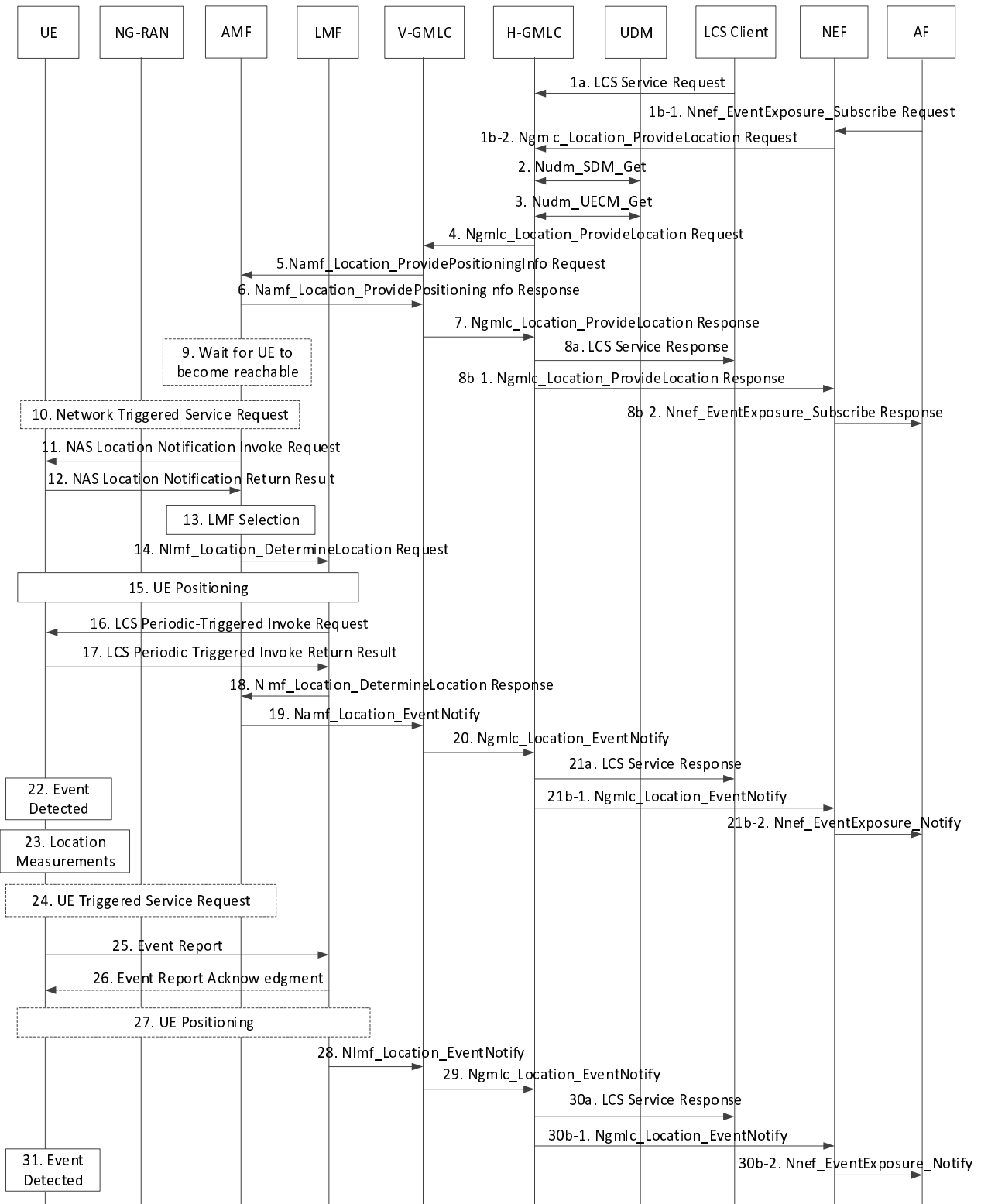


Figure 6.3.1-1: Deferred 5GC-MT-LR for periodic, triggered and UE available location events

1. The external location services client or the AF (via NEF) sends a request to the (H)GMLC for location reporting for periodic, triggered or UE available location events. The request is sent as described for step 1 in clause 6.1.2 with the differences described here. The LCS Service Request provides the type of periodic or triggered location reporting being requested and associated parameters. For periodic location, the LCS Service Request includes the time interval between successive location reports, the total number of reports and may include location QoS. For area event reporting, the LCS Service Request includes details of the target geographical area, whether the event to be reported is the UE being inside, entering into or leaving the target area, the duration of event reporting, the minimum and maximum time intervals between successive event reports, the maximum event

sampling interval, whether location estimates shall be included in event reports (and associated location QoS), and whether only one location report is required or more than one. If the target area is expressed by a local coordinate system or a geopolitical name, the (H)GMLC shall convert the target area to a geographical area expressed by a shape as defined in TS 23.032 [8]. For motion event reporting, the LCS Service Request includes the threshold linear distance, the duration of event reporting, the minimum and maximum time intervals between successive event reports, the maximum event sampling interval, whether location estimates shall be included in event reports (and associated location QoS), and whether only one location report is required or more than one.

1b-1 AF invokes the Nnef_EventExposure_Subscribe service operation to the NEF.

1b-2 The NEF forwards the request to the (H)GMLC. The NEF assigns a LDR reference number locally and sends it to (H-)GMLC,

2. The (H)GMLC may verify UE privacy requirements as for step 2 in clause 6.1.2. The (H)GMLC may also subscribe to and receive notification of UE privacy profile updates according to steps 0 and 4 of clause 6.12.1.
3. The (H)GMLC queries the UDM for the AMF address and, in the case of roaming, a VGMLC address as for step 3 in clause 6.1.2.

NOTE 1: The HGMLC may also query the HSS of the target UE for a serving MME address as described in clause 9.1.1 of TS 23.271 [4]. The deferred EPC-MT-LR procedure for Periodic and Triggered Location described in clause 9.1.19 of TS 23.271 [4] or the EPC-MT-LR procedure for the UE availability event described in clause 9.1.15 of TS 23.271 [4] may then be performed instead of steps 4-31 - e.g. if the HSS returns an MME address but the UDM does not return an AMF address.

4. This step is skipped for a non-roaming UE. For a roaming UE, the HGMLC obtains a VGMLC address if not received at step 3 and invokes the Ngmlc_Location_Provide Location Request service operation to forward the location request to the VGMLC as described for step 4 of in clause 6.1.2. The (H)GMLC also includes a contact address for the (H)GMLC (Notification Target Address, e.g. a URI) and an LDR reference number (Notification correlation ID) to be used for event reporting at steps 20 and 29. The LDR reference number is either allocated by (H-)GMLC based on predefined rule, e.g. operator's policy if the location request is received in step 1a, or allocated by NEF, if the location request is received in step 1b.
5. The (H)GMLC or VGMLC invokes the Namf_Location_ProvidePositioningInfo Request service operation to forward the location request to the serving AMF as described for step 5 in clause 6.1.2 and includes the (H)GMLC contact address and LDR reference number. The LDR reference number is either allocated by (H-)GMLC based on predefined rule, e.g. operator's policy if the location request is received in step 1a, or allocated by NEF, if the location request is received in step 1b. For area event reporting, the target geographical area is converted into a corresponding list of cell and/or tracking area identities.
- 6-8. If the AMF supports a deferred location request, the AMF returns an acknowledgment to the external LCS client, via the (H)GMLC and, in the case of roaming, the VGMLC, indicating that the request for deferred location was accepted. The VGMLC, when used, may optionally release resources for the deferred location request at this point.
9. If the UE is not currently reachable (e.g. is using eDRX or PSM), the AMF waits for the UE to become reachable.

NOTE 2: In the event of mobility of the UE to another AMF or to EPC when the UE becomes reachable, the old AMF can return an event indication to the (H)GMLC as at steps 19 and 20 and may include the address of the new serving AMF or MME if known. If a new serving AMF or MME is not known, the (H)GMLC can repeat step 3 to query the UDM and HSS for the new AMF or MME address. If a new AMF address is received, the (H)GMLC can restart the procedure from step 4.

10. Once the UE is reachable, if the UE is then in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.

NOTE 3: The AMF may decide to cancel the location request before the UE becomes reachable (e.g. due to lack of resources or due to a timeout on the UE becoming reachable) or when the UE becomes reachable (e.g. if the AMF executes NAS level congestion control on the UE, or for other reasons). The AMF then skips steps 10-18 and proceeds to step 19 to return an indication of location cancelation to the VGMLC or (H)GMLC.

- 11-12. The AMF performs steps 7-8 in clause 6.1.2 to notify the UE of the location request and verify privacy requirements if required by the location request received at step 5 and supported by the UE. The AMF includes in the notification to the UE the type of deferred location request in the case of periodic or triggered location.
13. The AMF selects an LMF as described for step 6 in clause 6.1.1. The selection may take into account the type of deferred location request (e.g. whether periodic or triggered) and any parameters for the deferred location request (e.g. the number of event reports required and/or the duration).
14. The AMF invokes the `Nlmf_Location_DetermineLocation` Request service operation towards the LMF to initiate a request for deferred UE location. For a request for periodic or triggered location, the service operation includes all the information received in step 4 or step 5 including the (H)GMLC contact address and LDR reference number and may include a list of allowed access types for event reporting at step 22. For a request for the UE available location event, the (H)GMLC contact address and LDR reference number are not included. In all cases, the service operation includes an LCS Correlation identifier, the AMF identifier, the serving cell identity, the client type and may include an indication if UE supports LPP, the required QoS and Supported GAD shapes.
15. The LMF performs one or more of the positioning procedures described in clause 6.11.1, 6.11.2 and 6.11.3 and as described for step 8 in clause 6.1.1. During this step, the LMF may request and obtain the UE positioning capabilities (e.g. which may indicate the type(s) of periodic and triggered location supported by the UE and the access types supported by the UE for event reporting). The LMF may also obtain the UE location - e.g. for a request for the UE available location event or when an initial location is requested for periodic or triggered UE location. For a request for the UE available location event, the LMF skips steps 16 and 17.
16. If periodic or triggered location was requested, the LMF sends a supplementary services LCS Periodic-Triggered Invoke Request to the UE via the serving AMF by invoking the `Namf_Communication_N1N2MessageTransfer` service operation. The LCS Periodic-Triggered Location Invoke carries the location request information received from the AMF at step 14, including the (H)GMLC contact address and LDR reference number. The LCS Periodic-Triggered Location Invoke also includes a deferred routing identifier, which can be the identification of the LMF when the LMF will act as a serving LMF or a default LMF identification otherwise. The LCS Periodic-Triggered Location Invoke may indicate the allowed access types for event reporting at step 25 (e.g. one or more of NR, E-UTRA connected to 5GC, E-UTRA connected to EPC, non-3GPP access connected to 5GC) and may include an embedded positioning message which indicates certain allowed or required location measurements (or a location estimate) at step 24 for each location event reported (e.g. based on the positioning capabilities of the UE obtained in step 14 and the allowed access types). As part of NAS transport of the LCS Periodic-Triggered Location Invoke from the serving AMF to the UE, the serving AMF includes an immediate routing identifier in the NAS transport message containing an LCS Correlation identifier - e.g. according to clause 6.11.1.
- NOTE 4: The deferred routing identifier may be global (e.g. an IP address, UUID or URI) or may be local. The deferred routing identifier is used for routing in step 25. However, the immediate routing identifier included by the AMF in step 15 is used for routing in step 17.
17. If the request in step 16 can be supported, the UE returns a supplementary services acknowledgment to the LMF, which is transferred via the serving AMF using the immediate routing identifier and delivered to the LMF using an `Namf_Communication_N1MessageNotify` service operation.
18. The LMF invokes the `Nlmf_Location_DetermineLocation` Response service operation towards the AMF to respond to the request at step 14. For a request for the UE available location event, the response includes any UE location obtained at step 15 and the LMF then releases all resources. For a periodic or triggered location request, the response includes any location obtained at step 15, a confirmation of whether periodic or triggered location was successfully activated in the UE according to steps 16 and 17 and the identification of the LMF in the case of successful activation with a serving LMF; the LMF also retains state information and resources for later steps if the LMF acts a serving LMF. If the UE cannot support the periodic and triggered location request, the service operation returned to the AMF shall include a suitable error cause.
19. The AMF invokes the `Namf_Location_EventNotify` service operation towards the VGMLC for roaming, or (H)GMLC for non-roaming, and includes any location received at step 18 and, for periodic or triggered location, a confirmation of whether or not periodic or triggered location was successfully activated in the target UE. The VGMLC, if used, may be the same VGMLC used in steps 5 and 6 or may be a different VGMLC. In the case of a different VGMLC, the AMF includes the HGMLC contact address and LDR reference number. The AMF also includes the LMF identification if received at step 18. The AMF may then release all resources for the location request and cease support for the procedure.
20. This step is skipped for a non-roaming UE. For a roaming UE, The VGMLC forwards the response received at step 19 to the HGMLC using the HGMLC contact address received at step 19 (for a different VGMLC) or

received and stored at step 4 (for the same VGMLC) and includes the LDR reference number and any LMF identification that was received. The VGMLC may then release all resources for the location request and cease support for the procedure.

NOTE 5: As an optional optimization for a roaming UE, instead of performing steps 19 and 20, the AMF may invoke the Namf_Location_EventNotify service operation directly towards the HGMLC (e.g. if a VGMLC is not used or if the VGMLC ceases support after step 8).

21. The (H)GMLC forwards the response to the external LCS client or AF (via the NEF). If the location request at step 1 was for the UE available location event, the procedure terminates here and further steps 22-31 are not performed.

22. For a periodic or triggered location request where steps 16 and 17 were successfully performed, the UE monitors for occurrence of the trigger or periodic event requested in step 16. For the area event or motion event, the UE monitors the requested event at intervals equal to or less than the maximum event sampling interval. An event trigger is detected by the UE when any of the following occur: (i) a requested area event or motion event has been detected and the minimum reporting time interval has elapsed since the last report (if this is not the first event report); (ii) a requested periodic location event has occurred; or (iii) the maximum reporting time for an area event or motion event has expired. When a trigger or periodic event is detected and if the UE is camped on or connected to (or can otherwise access) an access type allowed by the LMF at step 16, the UE proceeds to step 23. If the UE cannot access an allowed access type, the UE may skip reporting the trigger event or may report the trigger event at a later time when an allowed access type becomes available, according to requirements received from the LMF at step 16.

23. The UE obtains any location measurements or a location estimate that were requested or allowed at step 16.

NOTE 6: Obtaining a location estimate when requested also applies to the trigger event corresponding to expiration of the maximum reporting interval for an area event or motion event.

24. The UE performs a UE triggered service request as defined in clause 4.2.3.2 of TS 23.502 [19] if in CM-IDLE state in order to establish a signalling connection with the AMF.

25. The UE sends a supplementary services event report message to the LMF which is transferred via the serving AMF (which may be different to the original serving AMF for steps 14-16) and is delivered to the LMF using an Namf_Communication_N1MessageNotify service operation. The event report may indicate the type of event being reported (e.g. whether a normal event or expiration of the maximum reporting interval) and may include an embedded positioning message which includes any location measurements or location estimate obtained at step 23. The UE also includes the deferred routing identifier received in step 16 in the NAS Transport message used to transfer the event report from the UE to the AMF. The AMF then forwards the event report to either the serving LMF or any suitable LMF based on whether the deferred routing identifier indicates a particular LMF or any (default) LMF. If a different LMF than the serving LMF is used, procedure in clause 6.4 is used. The UE also includes the (H)GMLC contact address, the LDR reference number, whether location estimates are to be reported and if so the location QoS in the event report.

NOTE 7: When forwarding the event report message to the LMF in step 25, the AMF includes the deferred routing identifier received in step 25 as the LCS Correlation Identifier. The deferred routing identifier can assist a serving LMF in identifying the periodic or triggered location session if the same serving LMF had assigned the deferred routing identifier at step 16 or can indicate to the LMF that it is acting as a default LMF.

26. When the LMF receives the event report and if it can handle this event report, the LMF updates the status of event reporting (e.g. the number of event reports so far received from the UE and/or the duration of event reporting so far) and returns a supplementary services acknowledgment for the event report to the UE. The acknowledgment may optionally include a new deferred routing identifier indicating a new serving LMF or a default (any) LMF. If the UE does not receive any response from the LMF after a predefined time, i.e. the current LMF does not support the deferred location request (for temporary or permanent reasons) or due to some radio access failures, the UE may re-send the report one or more times. If the UE sends the repeated event report more than the predefined maximum resending time and the UE still does not receive any response from AMF, the UE shall stop resending the report and reserve the event report, then record a corresponding flag to indicate that a report has been sent unsuccessfully. When the UE performs location update and detects the PLMN is changed, if the flag has been set, the UE shall send the report to the corresponding AMF, and the flag will be cleared upon a success of the sending.

NOTE 8: Inclusion of a new deferred routing identifier in the event report acknowledgment at step 26 may be used to change the serving LMF (e.g. if a UE moves into an area or to an access type that is better supported by a different LMF or if the serving LMF is overloaded) or to enable a default LMF to become a serving LMF.

27. If a location estimate is needed for event reporting, the LMF may perform one or more of the positioning procedures described in clause 6.11.1, 6.11.2 and 6.11.3 and as described for step 8 in clause 6.1.1. The LMF then determines the UE location using the location measurements and/or location estimate(s) obtained at this step and/or received at step 25.

NOTE 9: A precondition for the procedure in clause 6.11.1 is that an LCS Correlation identifier assigned by the serving AMF has been previously passed to the LMF. The LCS Correlation identifier is used in steps 1, 3, 6 and 7 in clause 6.11.1 to ensure that during a positioning session between the LMF and UE, positioning response messages from the UE are returned by the AMF to the correct LMF and carrying an indication (the LCS Correlation identifier) which can be recognized by the LMF. To retain this capability in step 27, the LMF shall assign a Correlation identifier indicating the LMF (and optionally a positioning session) for use at step 1 in clause 6.11.1. To enable an AMF to distinguish a Correlation identifier assigned by an LMF (used in this procedure) from a Correlation identifier assigned by the AMF (used otherwise for clause 6.11.1), the two types of Correlation identifier could be selected from different ranges, with or without a flag.

28. In the case of roaming, the LMF selects a VGMLC (which may be different to the VGMLC for steps 3-8 and steps 19-21), The LMF then invokes an Nlmf_Location_EventNotify service operation towards the selected VGMLC or (H)GMLC with an indication of the type of event being reported, the (H)GMLC contact address and LDR reference number, the identification of the LMF if this is a serving LMF, and any location estimate obtained at step 27.

NOTE 10: In the case of roaming, the LMF may select the VGMLC for step 28 using the NRF service or using configuration information in the LMF or may use the same VGMLC as for steps 3-8 (e.g. if the LMF acts as a serving LMF and received the VGMLC address from the AMF as part of step 14).

29. This step is skipped for a non-roaming UE. For a roaming UE, the VGMLC invokes an Ngmlc_Location_EventNotify service operation to forward the information received in step 28 (e.g. including the type of event being reported, the LDR reference number and possibly the LMF identification) to the HGMLC which identifies the periodic and triggered location request from the LDR reference number.

NOTE 11: As an optional optimization for a roaming UE, instead of performing steps 28 and 29, the LMF may invoke the Nlmf_Location_EventNotify service operation directly towards the HGMLC.

NOTE 12: In the event of mobility of the UE to an access network for which event reporting at step 22 is not allowed (e.g. an access network in EPS) or if the UE is otherwise unable to send event reports (e.g. due to being powered off), the (H)GMLC may not receive event reports at step 28 or step 29 at fixed intervals for periodic location or at intervals equal to or less than the maximum reporting interval for triggered location. In such a case, the (H)GMLC may cancel the periodic or triggered location reporting using the procedures defined in clause 6.3.3. The UE may also cancel the periodic or triggered location reporting either locally or using the procedure defined in clause 6.3.2 once the UE can access an access network that is allowed for event reporting.

30. The (H)GMLC uses the LDR reference number received in step 28 or step 29 to identify the periodic and triggered location request received in step 1 and then sends the type of event being reported and any location estimate and used positioning methods to the external LCS client or AF (via the NEF), and sends the LDR reference number to LCS client. The (H)GMLC may also verify UE privacy requirements before reporting the event and any location to the external LCS client or AF.

31. The UE continues to monitor for further periodic or trigger events as in step 22 and instigates steps 23-30 each time a trigger event is detected.

NOTE 13: Service continuity for reporting of periodic or trigger events when a UE moves between 5GS and EPS is not supported in this release of the specification.

6.3.2 Cancellation of Reporting of Location Events by a UE

Figure 6.3.2-1 summarizes a procedure to enable a UE to cancel a deferred 5GC-MT-LR procedure for periodic, or triggered location events (e.g. if the UE is powered off or if the UE cancels the location request based on user's input). It is assumed that a deferred 5GC-MT-LR for periodic or triggered location events has already been initiated in the UE according to steps 1-17 for the procedure in clause 6.3.1. If a network entity (e.g. (H)GMLC, AMF or LMF) cancels a deferred 5GC-MT-LR procedure for periodic or triggered location events, part of the procedure in clause 6.3.3 for cancellation by an AF or external LCS Client would be used to cancel towards the UE and part of the procedure in this clause would be used to cancel towards the AF or external LCS Client.

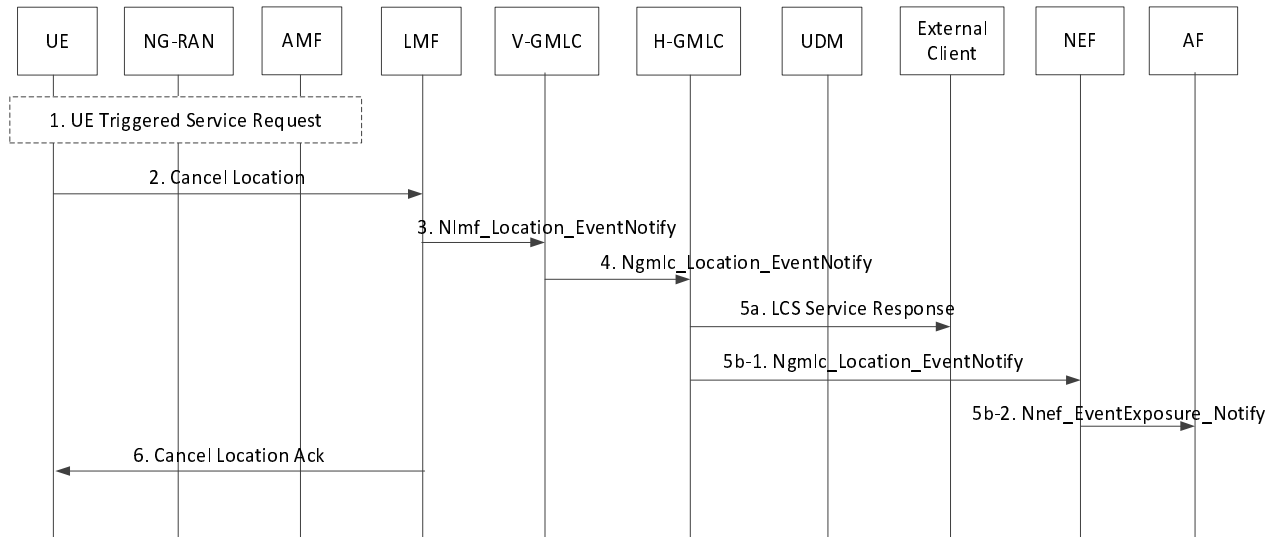


Figure 6.3.2-1: UE Cancellation of a Deferred 5GC-MT-LR for periodic or triggered location events

1. The UE performs a UE triggered service request as defined in clause 4.2.3.2 of TS 23.502 [19] if in CM-IDLE state in order to establish a signalling connection with the AMF.
2. The UE sends a Cancel Location request message to the LMF which is transferred via the serving AMF and is delivered to the LMF using an Namf_Communication_N1MessageNotify service operation. The UE includes the deferred routing identifier originally received in step 16 of the procedure in clause 6.3.1 (or as updated by step 26 in clause 6.3.1 or by the procedure in clause 6.4) in the NAS Transport message used to transfer the cancel location request from the UE to the AMF. The AMF then forwards the cancel location request to either the serving LMF or any suitable LMF based on whether the deferred routing identifier indicates a particular LMF or any (default) LMF. The UE also includes the (H)GMLC contact address and the LDR reference number.
3. In the case of roaming, the LMF selects a VGMLC. The LMF then invokes an Nlmf_Location_EventNotify service operation towards the selected VGMLC or (H)GMLC with an indication of the cancellation of location event reporting, the (H)GMLC contact address and LDR reference number.

NOTE 1: In the case of roaming, the LMF may select the VGMLC for step 3 using the NRF service or using configuration information in the LMF or may use the same VGMLC as for steps 3-8 of clause 6.3.1 (e.g. if the LMF acts as a serving LMF and received the VGMLC address from the AMF as part of step 14 of clause 6.3.1).

4. This step is skipped for a non-roaming UE. For a roaming UE, the VGMLC invokes an Ngmlc_Location_EventNotify service operation to forward the cancel location request (including the LDR reference number) to the HGMLC which identifies the periodic and triggered location request from the LDR reference number.

NOTE 2: As an optional optimization for a roaming UE, instead of performing steps 3 and 4, the LMF may invoke the Nlmf_Location_EventNotify service operation directly towards the HGMLC.

5. The (H)GMLC uses the LDR reference number received in step 3 or step 4 to identify the periodic and triggered location request received in step 1 of clause 6.3.1 and then forwards the cancel location to the external LCS client or AF (via the NEF).
6. The LMF returns an acknowledgment to the UE via the serving AMF.

6.3.3 Cancellation of Reporting of Location Events by an AF or External LCS Client or GMLC

Figure 6.3.3-1 summarizes a procedure to enable an AF or External LCS Client or GMLC to cancel a deferred 5GC-MT-LR procedure for periodic, or triggered location. It is assumed that a deferred 5GC-MT-LR for periodic or triggered location events has already been requested according to the procedure in clause 6.3.1 up until at least step 20.

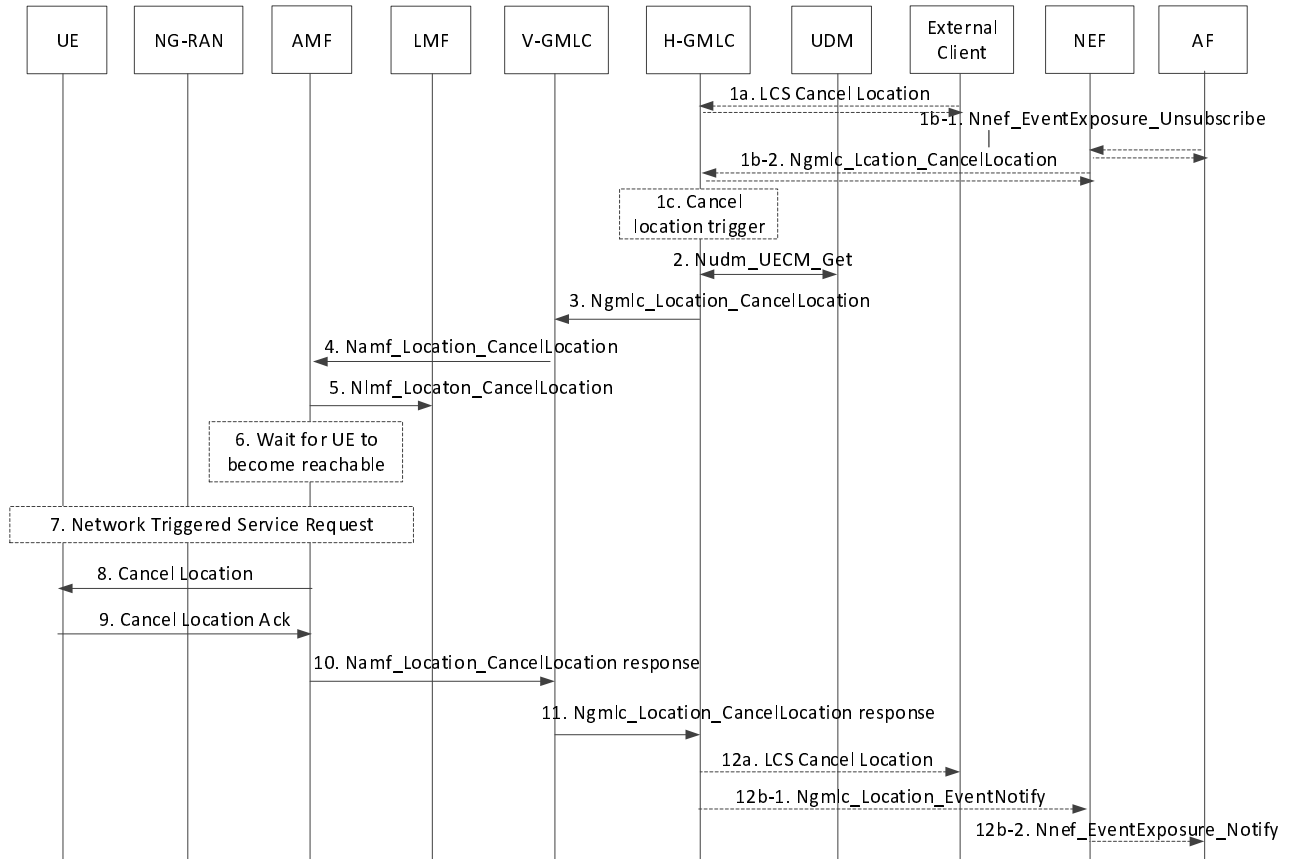


Figure 6.3.3-1: Cancellation of a Deferred 5GC-MT-LR for periodic or triggered location events by an AF or External LCS Client

1. The external LCS client or AF (via an NEF) send a request to cancel the periodic or triggered location to the (H)GMLC, the external LCS client or AF shall include the identity of the deferred request.

The HGMLC may itself initiate the cancellation procedure, e.g. when it is notified that the UE LCS privacy profile stored in the UDM was changed. For every outstanding Deferred Location Request against that UE, the HGMLC shall perform a new privacy check based on the updated UE LCS privacy profile stored in the UDM. If the privacy check passes, i.e. the LCS Client is still allowed to position the target UE, the handling of the outstanding Deferred Location Request shall be continued. Otherwise, if the privacy check does not pass, i.e. the Location estimate of the target UE is not allowed to be provided to the LCS Client, the HGMLC shall initiate a cancellation procedure

NOTE: GMLC may perform privacy check for more than one location request as a bulk operation.

2. The (H)GMLC queries the UDM to determine the serving AMF address as in step 3 of clause 6.3.1.
3. For a roaming UE, the HGMLC obtains a VGMLC address if not received at step 2 and invokes an Ngmlc_Location_CancelLocation service operation to forward the cancellation request to the VGMLC. The (H)GMLC also includes the contact address for the (H)GMLC and the LDR reference number in the request and the latest LMF identification received in step 20 or step 29 in clause 6.3.1 if either step has occurred and included an LMF identification.

4. The (H)GMLC or VGMLC invokes the Namf_Location_CancelLocation service operation to forward the cancellation request to the serving AMF and includes the (H)GMLC contact address, LDR reference number and LMF identification if available.
5. If an LMF identification was included in step 4, the AMF forwards the cancelation request to the indicated LMF by invoking an Nlmf_Location_CancelLocation service operation and includes the (H)GMLC contact address and LDR reference number. The LMF then releases all resources for the location request.
6. If the UE is not currently reachable (e.g. is using eDRX or PSM), the AMF waits for the UE to become reachable.
7. Once the UE is reachable, if the UE is then in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.
8. The AMF sends the cancelation request to the target UE and includes the (H)GMLC contact address and the LDR reference number. The UE then releases all resources for the location request.
9. The UE returns an acknowledgment to the AMF.
10. The AMF responds to Namf_Location_CancelLocation, then V-GMLC or (H)GMLC releases all resources for the location request. AMF releases all resources for the location request.
11. For a roaming UE, the VGMLC responds to Ngmlc_Location_CancelLocation, then HGMLC releases all resources for the location request.
12. [Conditional] If the cancellation procedure is requested by HGMLC (i.e. the procedure is triggered in step 1c) and the cancelled location event is reported to external client or AF (via NEF).

6.4 LMF Change Procedure

The LMF Change procedure supports change of a serving LMF during a deferred 5GC-MT-LR procedure for periodic, or triggered location events as defined in clause 6.3.1. When a serving LMF is used for the procedure in clause 6.3.1, mobility of the target UE may lead to a change of serving AMF for which the original serving LMF is not suitable. For example, the serving LMF may be very remote from the new serving AMF leading to higher resource utilisation for AMF to LMF signalling or the LMF may not be configured with information (e.g. a cell database) for the current access network for the UE to enable location. In such a case, the serving LMF may need to change. Figure 6.4-1 shows a procedure to enable change of the serving LMF when a UE sends an event report as at step 25 in clause 6.3.1.

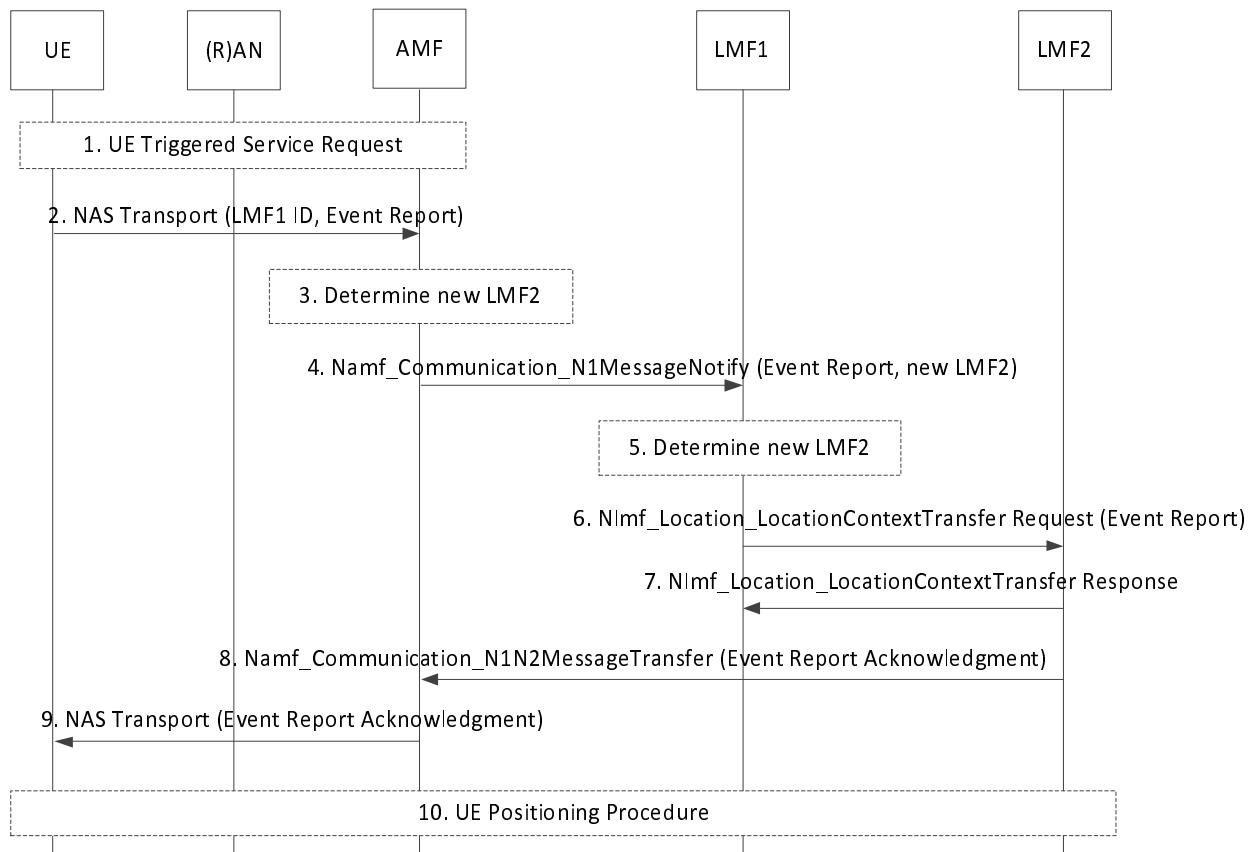


Figure 6.4-1: Change of serving LMF for periodic and triggered UE location events

Precondition: Steps 1-23 in clause 6.3.1 have already been performed and steps 22-30 may have been performed or repeated. A serving LMF is used and the current serving LMF is LMF1.

1. The UE performs a service request if needed as for step 24 in clause 6.3.1.
2. The UE sends a NAS Transport message containing a supplementary services event report message to the serving AMF. The NAS Transport message includes a deferred routing identifier indicating LMF1. Step 2 corresponds to part of step 25 for clause 6.3.1.
3. Based on operator configuration and policy, the AMF may evaluate and determine that LMF1 is unsuitable or unable to support location for the current UE access network or serving cell and determines LMF2 as being a more suitable LMF.
4. The AMF invokes the `Namf_Communication_N1MessageNotify` service operation towards LMF1. The service operation includes the event report received in step 2. If the AMF determined in step 3 that a new LMF2 should be used, it indicates that to the LMF1 as well.
5. If the AMF did not indicate a new LMF in step 4, based on the operator configuration and policy, LMF1 may evaluate and determine that it is unsuitable or unable to support location for the current UE access network or serving cell and determines LMF2 as being a more suitable LMF.
6. LMF1 invokes an `Nlmf_Location_LocationContextTransfer Request` service operation towards LMF2 to provide the current location context of the UE and includes the event report message received in step 4. The service operation includes the AMF identity and all the information originally received by LMF1 for the periodic or triggered location request either from the AMF according to the procedure in clause 6.3.1 or from an earlier serving LMF according to this procedure. The service operation may also include the current status of event reporting (e.g. the number of event reports so far received from the UE and/or the duration of event reporting so far) and may include location related information for the UE such a previous location estimate or location measurements.
7. LMF2 informs LMF1 of the location context transfer operation results. LMF1 then releases all resources for the procedure.

8. LMF2 invokes the Namf_Communication_N1N2MessageTransfer service operation towards the AMF to request the transfer of a supplementary services Event Report Acknowledgment message to the UE. The Event Report Acknowledgment indicates a change of LMF and includes a deferred routing identifier indicating LMF2.
9. The AMF forwards the Event Report Acknowledgment to the UE in a NAS Transport message. The AMF also informs the LMF2 of the result of the delivery of the Event Report Acknowledgement.
10. If a location estimate is needed for event reporting, LMF2 may perform positioning of the UE and determines the UE location as at step 27 in clause 6.3.1. The rest of the procedure in clause 6.3.1 then continues from step 28 with LMF2 retaining state information to enable support of subsequent event reports from the UE.

6.5 Unified Location Service Exposure Procedure

6.5.1 Unified Location Service Exposure Procedure without routing by a UDM

Figure 6.5.1-1 shows a unified location service exposure procedure provided by an NEF in an HPLMN for a target UE to an NF in the HPLMN or to an external AF outside the HPLMN. The procedure enables a request for an immediate location or for a deferred location for a target UE.

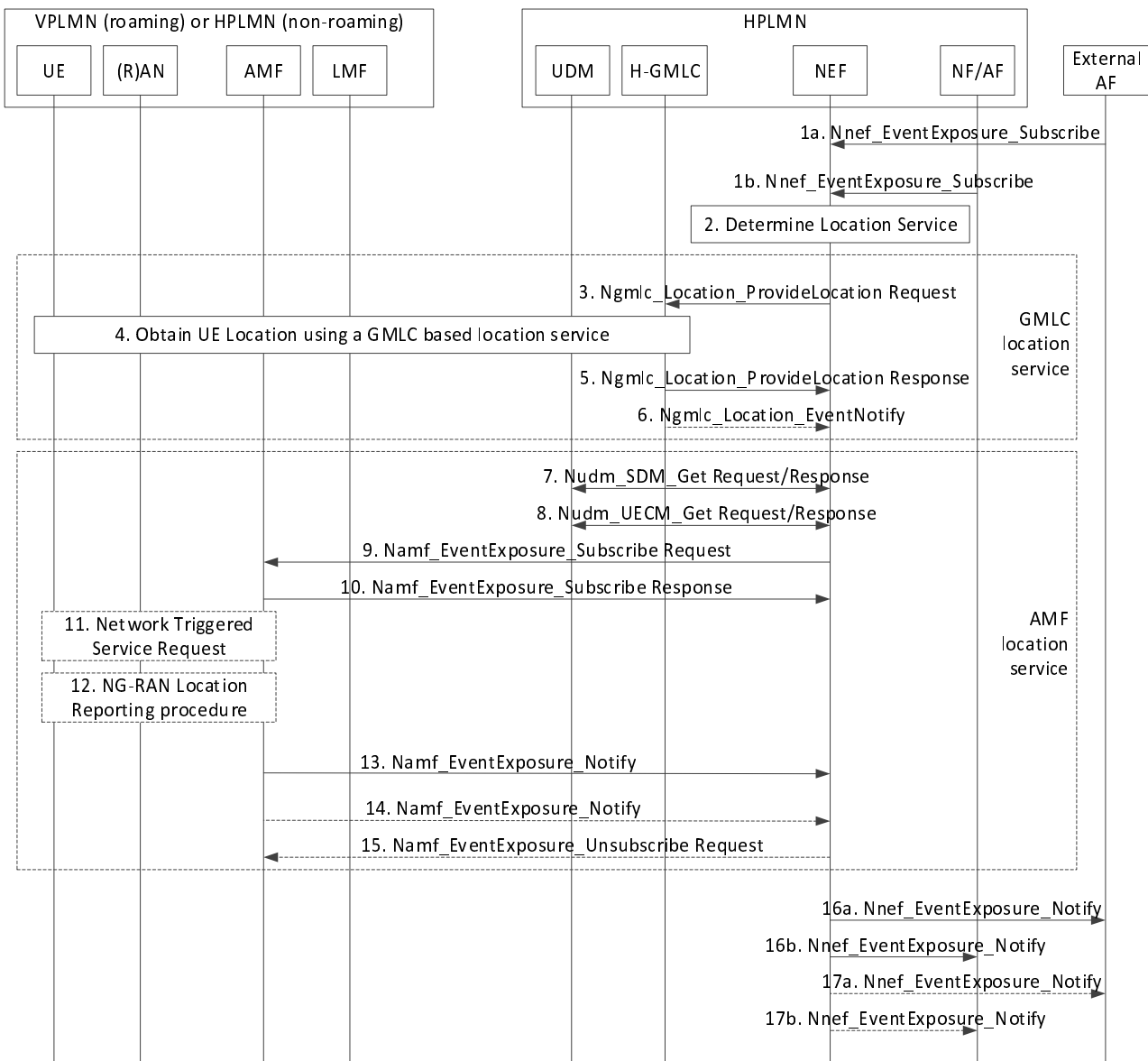


Figure 6.5.1-1: Unified Location Service Exposure Procedure without routing by a UDM

- 1a. An external AF invokes an Nnef_EventExposure_Subscribe service operation towards an NEF in the HPLMN for a target UE and includes an identification of the UE (e.g. SUPI or GPSI) and details of the location request such as whether a current or last known immediate location or a deferred location is requested, the location accuracy and response time, LDR request information and other information applicable to the type of request.
- 1b. As an alternative to step 1a, a consumer NF in the HPLMN for a target UE invokes an Nnef_EventExposure_Subscribe service operation towards an NEF in the HPLMN and includes a global identification of the UE (e.g. SUPI or GPSI) and details of the location request as in step 1a.
2. Based on the service requirements in step 1a or step 1b (e.g. location QoS and whether an immediate or deferred location is requested) and on the availability of GMLC versus AMF based location service, the NEF determines whether the location request in step 1a or step 1b can be mapped to a GMLC based location service or to an AMF location event exposure service. The NEF determines to use whichever mapping is supported or, when both mappings are supported, may employ implementation or operator dependent procedures to make a choice. When a GMLC based location service is determined, steps 3-6 are performed and steps 7-15 are omitted. When an AMF location event exposure service is determined, steps 7-15 are performed and steps 3-6 are omitted. If NEF determines the location request is handled by AMF, it allocates an LDR reference number.

NOTE 1: The NEF may take the potential load to the system, e.g. AMF/UDM load, or GMLC load, into consideration when deciding which location service to use, or whether to reject the request from NF or AF. The NEF may also take into account QoS. For example, when QoS accuracy exceeds cell ID, the GMLC location service shall be used if available.

3. When a GMLC based location service is determined in step 2, the NEF invokes an Ngmlc_Location_ProvideLocation Request service operation towards an HGMLC in the HPLMN. The service operation may include all of the information received from the AF or NF in step 1a or 1b.
4. For a request for an immediate location, the HGMLC performs steps 2-10 of the 5GC-MT-LR procedure in clause 6.1.1 in the case of regulatory location or steps 2-23 of the 5GC-MT-LR procedure in clause 6.1.2 in the case of commercial location. For a request for deferred location, the HGMLC performs steps 2-29 of the deferred 5GC-MT-LR procedure for periodic, triggered or UE available location events in clause 6.3.1.
5. The HGMLC invokes the Ngmlc_Location_ProvideLocation Response service operation towards the NEF to confirm the request in step 3 for a request for deferred location or to return the UE location for a request for an immediate location.
6. If deferred location was requested in step 1, the HGMLC invokes one or more Ngmlc_Location_EventNotify service operations towards the NEF, to convey a single UE location in the case of deferred location for the UE available event or to convey an indication of location activation in the UE followed by one or more location event reports in the case of deferred location for periodic or triggered location events.
7. When an AMF location event exposure service is determined in step 2, if the NEF needs to verify the target UE privacy requirements, the NEF invokes a Nudm_SDM_Get service operation towards the UDM of the target UE to get the privacy settings of the UE identified by its GPSI or SUPI. The UDM returns the target UE Privacy setting and the SUPI of the UE. The NEF checks the privacy settings. If the target UE is not allowed to be located, steps 8-14 are skipped.

NOTE 2: The AMF location event exposure service does not support a real time query to the UE to verify UE privacy requirement by the user. If the NEF finds this is needed, the NEF either selects a GMLC location service or returns an error to the external AF or NF.

8. The NEF invokes a Nudm_UECM_Get service operation towards the UDM of the target UE with SUPI of this UE. The UDM returns the network addresses of the current serving AMF. If the location request is an immediate location request, the NEF checks the country codes of the serving node addresses. If the NEF finds out the current AMF locates out of the service coverage, the NEF returns an appropriate error message to the AF or NF.

When the UE is concurrently served by multiple PLMNs respectively for 3GPP access and non-3GPP access, multiple AMF IDs with corresponding access type are provided by the UDM, the NEF selects one access type and its associated AMF based on principle defined in clause 5.3.2.

9. The NEF invokes an Namf_EventExposure_Subscribe service operation towards the serving AMF for the target UE and indicates whether a one-time UE location is requested or multiple UE locations for some triggering event and includes information on location accuracy (e.g. cell ID or TA granularity). If the NEF has no direct access to AMF or is configured to use UDM for the AMF event exposure, procedure in clause 6.5.2 is used instead.

10. The AMF responds to the service operation in step 9.
11. If the UE is currently reachable and in CM-IDLE state and if location is requested in step 9 with a cell ID accuracy, the AMF perform a network triggered service request as described in TS 23.502 [19] to place the UE in CM-CONNECTED state.
12. If an immediate location is requested in step 9 which the AMF can support based on AMF knowledge of the current or last known serving cell or serving TA for the UE, the AMF uses this information. Otherwise, the AMF invokes the NG-RAN location reporting procedure defined in clause 4.10 of TS 23.502 [19] to obtain a single location or multiple UE locations according to the request in step 9. The AMF may convert any location that was obtained in the form of a cell ID or TAI into geographical information based on TS 23.032 [8] and as defined in TS 29.518 [16] clause 6.2.6.2.5 and TS 29.571 [33], clauses 5.4.4.7, 5.4.4.8 and 5.4.4.9 before proceeding to step 13.
13. The AMF invokes the Namf_EventExposure Notify service operation towards the NEF to provide the current or last known UE location as obtained at step 12.

When the NEF obtains more than one serving AMF and corresponding access type from UDM at step 8, if the location information provided by AMF can not meet the required LCS QoS, the NEF may forward the location request to another AMF, i.e. Steps 9-15 is performed in another PLMN served by this AMF. In this case, if the access type associated with another AMF is non-3GPP access, procedure defined in clause 6.9.2 applies.

14. If the AMF invokes the NG-RAN location reporting procedure in step 12 to obtain multiple UE locations and receives multiple location reports from NG-RAN as part of step 12, the AMF invokes one or more additional Namf_EventExposure Notify service operations towards the NEF to provide each additional UE location provided by NG-RAN. The AMF may convert each additional UE location in the form of a cell ID or TAI into geographical information as in step 12.

NOTE 4: AMF conversion of a UE location in the form of a cell ID or TAI into geographical information in step 12 and step 14 can be PLMN operator dependent. However, it is expected that AMF conversion will normally be needed for a roaming UE to avoid VPLMN cell ID and TAI configuration in the HPLMN NEF.

15. In the case of LDR, the NEF may itself initiate the Namf_EventExposure Unsubscribe service operation, e.g. if when the UE's privacy setting stored in the UDM was changed. For every outstanding Deferred Location Request against that UE, the NEF shall perform a new privacy check based on the updated privacy setting stored in the UDM. If the privacy check passes, i.e. the LCS Client is still allowed to position the target UE, the handling of the outstanding Deferred Location Request should be continued. Otherwise, if the privacy check does not pass, i.e. the Location estimate of the target UE is not allowed to be provided to the LCS Client, the NEF shall initiate a cancellation. Then AMF then releases all resources for the LDR request, and NEF shall send a notification of cancellation of LDR request to consumer AF or NF in the step 17a, 17b.

16a, 16b. The NEF returns the first UE location received at step 5 or step 13 or a confirmation of a request for deferred location received at step 5 in the case of a GMLC location service to the external AF (step 15a) or NF (step 15b).

17a, 17b. If one or more additional location reports are received at step 6 or step 14, the NEF returns one or more additional locations to the external AF (step 16a) or NF (step 16b). If step 15 occurs, a notification of cancellation of LDR request shall be sent to the consumer AF (step 17a) or consumer NF (step 17b).

NOTE 5: As part of step 16 and step 17, the NEF converts any UE location received in the form of a cell ID or TAI into geographical information prior to sending the location to a consumer AF or NF.

6.5.2 Unified Location Service Exposure Procedure with routing via a UDM

Figure 6.5.2-1 shows the procedure used by an NEF to access the serving AMF for the UE when the NEF does not have direct access to the serving AMF or is configured to use UDM for AMF location event exposure service. When this procedure is used, steps 1-8 in Figure 6.5.2-1 replace steps 8-14 in Figure 6.5.1-1.

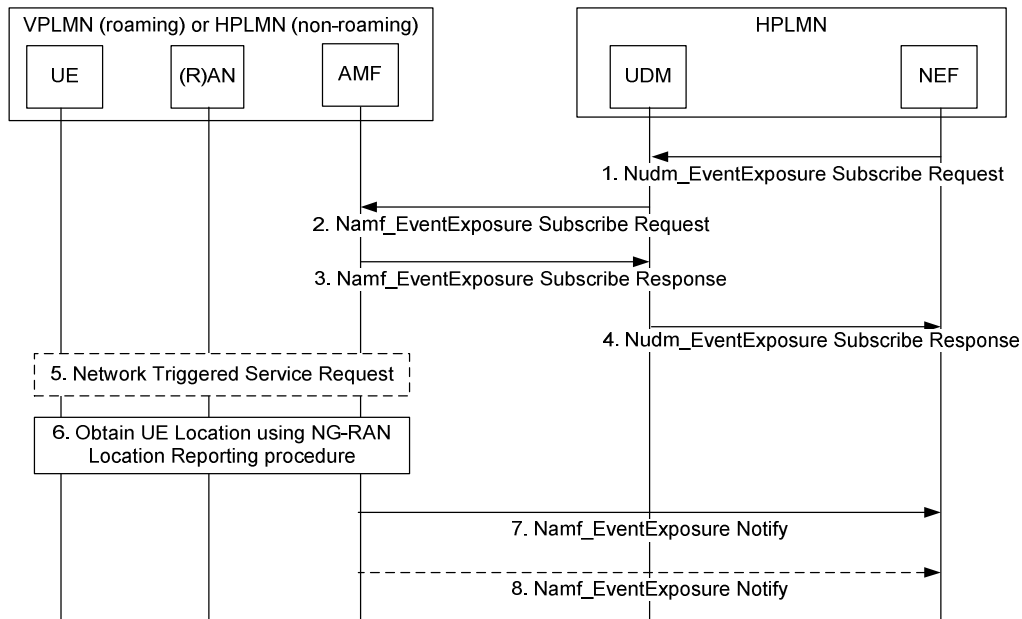


Figure 6.5.2-1: Unified Location Service Exposure Procedure with routing by a UDM

1. The NEF invokes an Nudm_EventExposure Subscribe service operation towards the UDM for the target UE for location reporting and indicates whether a one-time UE location is requested or multiple UE locations for some triggering event and includes the UE identity (SUPI or GPSI) and information on location accuracy (e.g. cell ID or TA granularity). A correlation ID is also included.
2. The UDM invokes an Namf_EventExposure Subscribe service operation towards the serving AMF for the target UE for location reporting and includes the information received in the service operation for step 1 including the correlation ID and a URI for the NEF.
3. The AMF responds to the service operation in step 2.
4. The UDM responds to acknowledges the service operation in step 1.
5. The AMF performs a Network Triggered Service Request if needed as for step 11 of clause 6.5.1.
6. The AMF obtains a location of the UE or invokes a location reporting procedure with NG-RAN to obtain a UE location or multiple UE locations as for step 12 of clause 6.5.1.
7. The AMF invokes the Namf_EventExposure Notify service operation towards the NEF indicated by the URI received in step 2 and includes the first UE location obtained at step 6 and the correlation ID received at step 2.
8. If the AMF invokes a location reporting procedure with NG-RAN to obtain multiple UE locations at step 6, the AMF invokes one or more Namf_EventExposure Notify service operations towards the NEF to provide each additional UE location as in step 14 for clause 6.5.1.

6.6 NG-RAN Location Service Exposure Procedure

The NG-RAN Location Service Exposure procedure is not supported in this Release of the specification.

6.7 Low Power Periodic and Triggered 5GC-MT-LR Procedures

The low power periodic and triggered 5GC-MT-LR procedures may be used to support a request from an external LCS client or AF for deferred location for periodic or triggered location events. The procedures may be used as alternatives to the procedures in clause 6.3.1 and clause 6.4. If the procedures are used, cancellation of the reporting of location events is still supported using the procedures in clause 6.3.2 and clause 6.3.3.

6.7.1 Event Reporting with no change of LMF

Figure 6.7.1-1 summarizes the initiation and reporting of location events for a deferred 5GC-MT-LR procedure for Periodic or Triggered Location Events using low power event reporting.

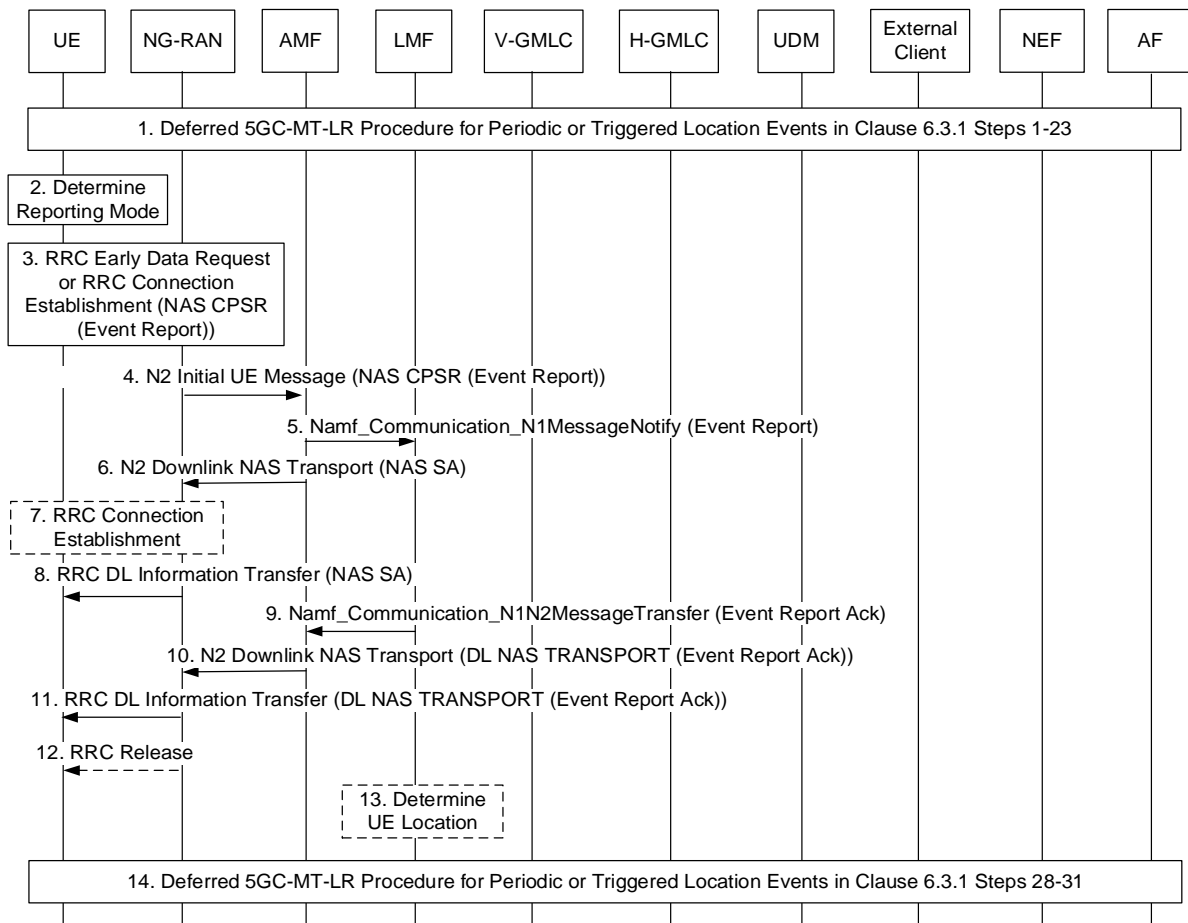


Figure 6.7.1-1: Low Power Periodic and Triggered 5GC-MT-LR Procedure with no change of LMF

1. Steps 1-23 for the deferred 5GC-MT-LR procedure for periodic or triggered location events in clause 6.3.1 are performed with the following exceptions.
 - At step 14, the AMF includes an indication in the Nlmf_Location_DetermineLocation Request service operation that the UE supports and is allowed to use Control Plane CIoT 5GS Optimisation as described in TS 23.501 [18] clause 5.31.4.
 - At step 16, if the AMF indicates the UE supports and is allowed to use Control Plane CIoT 5GS Optimisation at step 14 and if the LMF decides to allow Control Plane CIoT 5GS Optimisation, the LMF includes an indication in the LCS Periodic-Triggered Invoke Request that the UE is allowed to use Control Plane CIoT 5GS Optimisation to send Event Reports. The LMF may also include criteria indicating when Control Plane CIoT 5GS Optimisation may be used to send Event Reports. The criteria may include a maximum duration for sending Event Reports using Control Plane CIoT 5GS Optimisation, a maximum number of consecutive Event Reports to be sent using Control Plane CIoT 5GS Optimisation or both.

NOTE 1: As part of negotiating 5G network behaviour during registration, a UE indicates in a Registration Request whether Control Plane CIoT 5GS Optimisation is supported for location event reporting. This indication may be passed to the LMF by the AMF at step 14 for clause 6.3.1.

2. The UE determines whether to report the event detected at step 22 in clause 6.3.1 using Control Plane CIoT 5GS Optimisation or using a NAS signalling connection. If the UE is currently in CM CONNECTED state, the UE shall use a NAS signalling connection. Otherwise, the determination shall be based on criteria received from the LMF at step 14 in clause 6.3.1 when criteria are received. When the criteria include a maximum duration for sending event reports using Control Plane CIoT 5GS Optimisation, the UE shall report the event using a NAS

signalling connection if the UE has not used a NAS signalling connection to report events during an immediately preceding time interval equal to the maximum duration. When the criteria include a maximum number of consecutive Event Reports to be sent using Control Plane CIoT 5GS Optimisation, the UE shall report the event using a NAS signalling connection if the UE has used Control Plane CIoT 5GS Optimisation to report each of the N previous events, where N equals the maximum number of consecutive Event Reports. In other cases, Control Plane CIoT 5GS Optimisation may be used to report the event if supported by the 3GPP access type. If use of a NAS signalling connection is determined, steps 24-31 for the procedure in clause 6.3.1 are performed and steps 3-11 below are skipped. If use of Control Plane CIoT 5GS Optimisation is determined, steps 3-11 below are performed.

3. If the UE and NG-RAN node both support EDT, the UE sends an RRCEarlyDataRequest message to the NG-RAN node and includes a NAS control plane service request. Otherwise, the UE established an RRC connection with the NG-RAN node and sends the NAS control plane service request. The NAS control plane service request includes an event report message which includes the information described in step 25 in clause 6.3.1 (e.g. the type of event being reported and any location measurements or location estimate obtained at step 23 in clause 6.3.1). The control plane service request also includes the deferred routing identifier received in step 16 in clause 6.3.1. The UE also includes a NAS Release Assistance Indication (NAS RAI) in the NAS message. The NAS RAI indicates a single response is expected.

NOTE 2: Event reporting using Control Plane CIoT 5GS Optimisation requires a single Event report acknowledgment from the LMF.

4. The NG-RAN node forwards the NAS message to the AMF in an N2 Initial UE message and includes an "EDT Session" indication if EDT was used at step 3.
5. The AMF checks the integrity of the NAS message and deciphers its contents. The AMF then invokes an Namf_Communication_N1MessageNotify service operation to forward the event report to either the serving LMF or any suitable LMF as described for step 25 for clause 6.3.1. The AMF includes an indication of Control Plane CIoT 5GS Optimisation in the service operation and the serving cell ID.
6. The AMF returns a NAS Service Accept to the NG-RAN node which is encapsulated in an N2 Downlink NAS Transport message.
7. If EDT was used at step 3, the NG-RAN node establishes an RRC connection to the UE.
8. The NG-RAN node sends an RRC DL Information Transfer message to the UE and includes the NAS Service Accept message received in step 6.
9. The LMF invokes an Namf_Communication_N1N2MessageTransfer operation to return an acknowledgment for the event report as described for step 26 for clause 6.3.1.
10. The AMF forwards the acknowledgment to the NG-RAN node in a NAS DL NAS Transport message which is encapsulated in an N2 Downlink NAS Transport message. The AMF also includes an "end indication" in the N2 message.

NOTE 3: If the AMF determines more data or signalling may be pending for the UE, the AMF does not include the "end indication" at step 10 and step 12 below is not performed.

11. The NG-RAN node sends an RRC DL Information Transfer message to the UE and includes the NAS message received in step 10.
12. If the "end indication" was received in step 10, the NG-RAN node releases the RRC connection.
13. If a location estimate is needed for event reporting, the LMF determines the UE location using the location measurements and/or location estimate received in the event report at step 5 and/or the serving cell ID provided by the AMF at step 5.

NOTE 4: The LMF does not attempt to obtain additional location measurements from the UE or from the NG-RAN.

14. Steps 28-31 for clause 6.3.1 are performed to send the event report to the external client or AF and to continue event detection at the UE.

6.7.2 Event Reporting with change of LMF

Figure 6.7.2-1 shows a procedure to enable change of the serving LMF when a UE sends an event report as at steps 3 and 4 in clause 6.7.1.

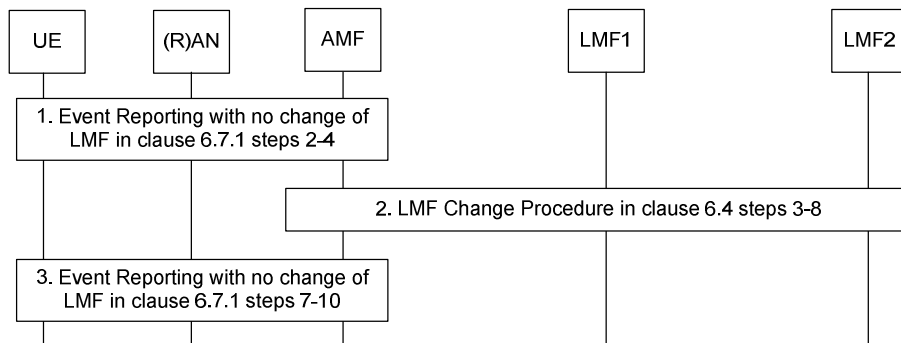


Figure 6.7.2-1: Event Reporting with change of LMF

Precondition: Step 1 in clause 6.7.1 has already been performed and steps 2-11 in clause 6.7.1 may have been performed or repeated. A serving LMF is used and the current serving LMF is LMF1.

1. Steps 2-4 for Event Reporting for no change of LMF in clause 6.7.1 are performed with the following exceptions.
 - At step 3, the NAS control plane service request includes a deferred routing identifier indicating LMF1.
2. Steps 3-8 for the LMF Change procedure in clause 6.4 are performed with the following exceptions.
 - At step 4, the `Namf_Communication_N1MessageNotify` service operation includes an indication of Control Plane CIoT 5GS Optimisation.
 - At step 6, the `Nlmf_Location_LocationContextTransfer Request` service operation includes an indication of Control Plane CIoT 5GS Optimisation and the serving cell ID.
3. Steps 7-10 for Event Reporting for no change of LMF in clause 6.7.1 are performed with LMF2 replacing the LMF in clause 6.7.1. The rest of the procedure in clause 6.7.1 then continues in step 11 with LMF2 retaining state information to enable support of subsequent event reports from the UE.

6.8 Bulk Operation of LCS Service Request Targeting to Multiple UEs

The procedure described in this clause applies to 5GC_MT_LR and Deferred 5GC-MT-LR request targeting to a group of UE identified by an external/internal group ID, if available.

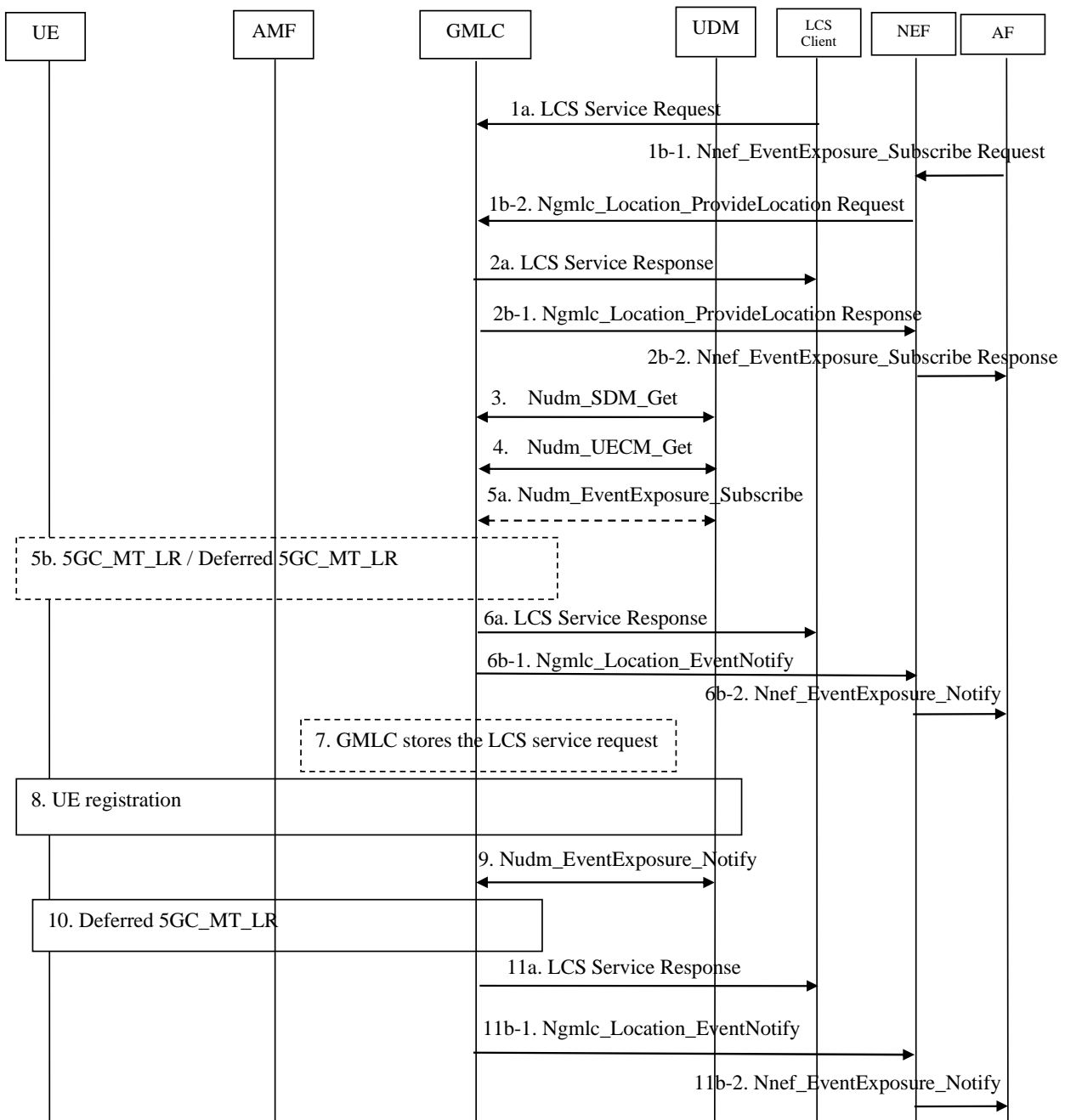


Figure 6.8-1: Bulk operation of LCS service request targeting to multiple UEs

1. This step is the same as step 1 of clause 6.1.2 and step 1 of clause 6.3.1, with the difference that the LCS request is targeting a group of UE identified by a group ID. The GMLC may map the external/internal group ID to the list of UE ID (i.e. SUPI) using Nudm_SDM_Get (Group Identifier Translation, External Group Identifier) service operation.

NOTE: Step 1b-1 assumes the LCS QoS provided by AF indicate "high-accuracy", and NEF determines the location request is handled by GMLC.

1b-2. The NEF shall send a Ngmlc_Location_ProvideLocation Request to the GMLC with the group of UE identified by a group ID to indicate a bulk operation procedure. If deferred location is requested the NEF shall include an Event type to indicate that deferred location is requested and provides an LDR reference number (Notification Correlation ID) to be used for event reporting at steps 6b-1 and 11b-1. If immediate location is requested the NEF shall not provide an Event type to indicate that immediate location is requested and provides a Notification Correlation ID to be used for reporting at steps 6b-1.

2a. If deferred location is requested from the LCS Client, the GMLC responds with an acknowledgment.

2b-1. The GMLC responds with a Ngmlc_Location_ProvideLocation Response.

GMLC may decide whether completely or partially (i.e. accept part of the UE(s) within the group identified by the group ID in step 1) reject the location request. If GMLC decides to partially reject the location request, GMLC will respond to the LCS client /AF with a proper error cause.

2b-2. The NEF acknowledges the execution of the Nnef_EventExposure_Subscribe.

Steps 3 to 5 are carried out once per UE.

3. The GMLC invokes a Nudm_SDM_Get (LCS privacy, SUPI) service operation towards the UDM to get the UE LCS privacy profile of the target UE. The GMLC checks the privacy settings. For the UE whose privacy setting does not allow it to be located, steps 4 and 5 are skipped. The GMLC may also subscribe to and receive notification of UE privacy profile updates according to steps 0 and 4 of clause 6.12.1.
4. The GMLC invokes a Nudm_UECM_Get service operation towards the UDM of the target UE with SUPI of this UE. The UDM returns the current serving AMF ID to the GMLC.

5a. If no AMF ID is returned at step 4:

- if it is a deferred location request and the GMLC supports the storage of the LCS service request for a group of UE, the GMLC subscribes the UE reachability status to the UDM using Nudm_EventExposure_Subscribe service operation with the data key "SUPI";
- otherwise, this step is skipped and the GMLC returns an appropriate error cause to the LCS client or NEF at step 6.

5b. If the UDM returns the current serving AMF ID to the GMLC at step 4:

- the GMLC initiates 5GC_MT_LR procedure (from step 4 onwards) as described in clause 6.1.2, with the difference that Step 24 is skipped (as it is replaced by step 6 below); The GMLC shall not include the Notification Correlation ID received from NEF in step 1b-2.
- or the GMLC initiates Deferred 5GC-MT-LR Procedure (from step 4 onwards) as described in clause 6.3.1 with the difference that steps 8,21 and 30 are skipped (as it is replaced by steps 2, 6 and 11 below) and that GMLC assign LDR reference numbers (separate number for each UE) to be used for event reporting at steps 20 and 29.

6a. The GMLC receives response messages as defined in clause 6.1.2 step 22 or 23 or GMLC receives notification messages as defined in clause 6.3.1 step 28 or 29. The GMLC sends one or more LCS Service Responses to the LCS Client to convey UE locations or event reports.

6b-1. The GMLC receives response messages as defined in clause 6.1.2 step 22 or 23 or GMLC receives notification messages as defined in clause 6.3.1 step 28 or 29. The GMLC maps the messages to the Request received in step 1b-2 and invokes one or more Ngmlc_Location_EventNotify service operations towards the NEF to convey UE locations or event reports. GMLC may aggregate one or more UE location estimates / event reports in each message sent to NEF.

6b-2. The NEF invokes one or more Nnef_EventExposure_Notify service operations towards the AF, to convey UE locations or event reports , received from GMLC in step 6b-1.

7. For the deferred location request, if any UE in the group didn't get its serving AMF ID at step 4, the GMLC may store the LCS service request locally if the GMLC supports the storage of the LCS service request for a group of UE; otherwise, this step is skipped.

Further steps apply to the UEs of the group who was not registered to the network when the LCS service request is received at GMLC.

8. UE performs the registration as described in clause 4.2.2 of TS 23.502, during which an AMF is selected to serve the UE, and the AMF ID is stored into UDM.
9. UDM notifies the GMLC who had subscribed the UE registration at step 5a using Nudm_EventExposure_Notify service operation, which includes "SUPI" and UE registration status.
10. GMLC initiates Deferred 5GC-MT-LR Procedure as described in step 5b.

11a. The GMLC receives notification messages as defined in clause 6.3.1 step 28 or 29. The GMLC sends one or more LCS Service Responses to the LCS Client to convey UE locations or event reports.

11b-1. The GMLC receives notification messages as defined in clause 6.3.1 step 28 or 29. The GMLC maps the messages to the Request received in step 1b-2 and invokes one or more Ngmlc_Location_EventNotify service operations towards the NEF to convey UE locations or event reports. GMLC may aggregate one or more UE location estimates / event reports in each message sent to NEF.

11b-2. The NEF invokes one or more Nnef_EventExposure_Notify service operations towards the AF, to convey event reports received from GMLC in step 11b-1.

6.9 Procedures to Support Non-3GPP Access

6.9.1 Common Positioning Procedures when a UE is served by only one PLMN

Figure 6.9.1-1 shows the common positioning procedures to support location services with non-3GPP access when UE is served by only one PLMN, which provides either non-3GPP access only or both 3GPP access and non-3GPP access. The common positioning procedures can be triggered by:

- 5GC-NI-LR procedure (described in clause 6.10.1), which assumes that the serving AMF is aware of the emergency session initiation - e.g. due to supporting an Emergency Registration procedure or assisting in establishing an emergency PDU Session. If such emergency session procedure is initiated via non-3GPP access, the AMF provides access type to LMF in step 2 in clause 6.10.1, the LMF shall use the access type provided by AMF in step 2 in clause 6.9.1; or
- 5GC-MT-LR procedure (described in clause 6.1.1 and 6.1.2 and 6.10.2), which is applicable to a request from an LCS client for a current location.
- 5GC-MO-LR procedure (described in clause 6.2), for this case, the access type is selected by the UE using the UE Local Configuration to initiate MO-LR procedure which is the same as the 5GC-MO-LR Procedure in clause 6.2 with following differences:
 - The AMF shall in step 4 of clause 6.2 include UE connectivity state per access type.
 - In step 5 of clause 6.2 the modification in this clause shall be applied, the LMF shall also determine positioning methods and the positioning access type, which can be different with the access type selected by the UE.
- Deferred 5GC-MT-LR procedure for periodic, triggered and UE available location events (described in clause 6.3.1), which is applicable to report of location event for a deferred 5GC-MT-LR procedure.
- Unified Location Service Exposure Procedure (described in clause 6.5), which allows an NEF to provide location service exposure to an NF in HPLMN or to an external AF outside the HPLMN when requested by the NF or the AF.

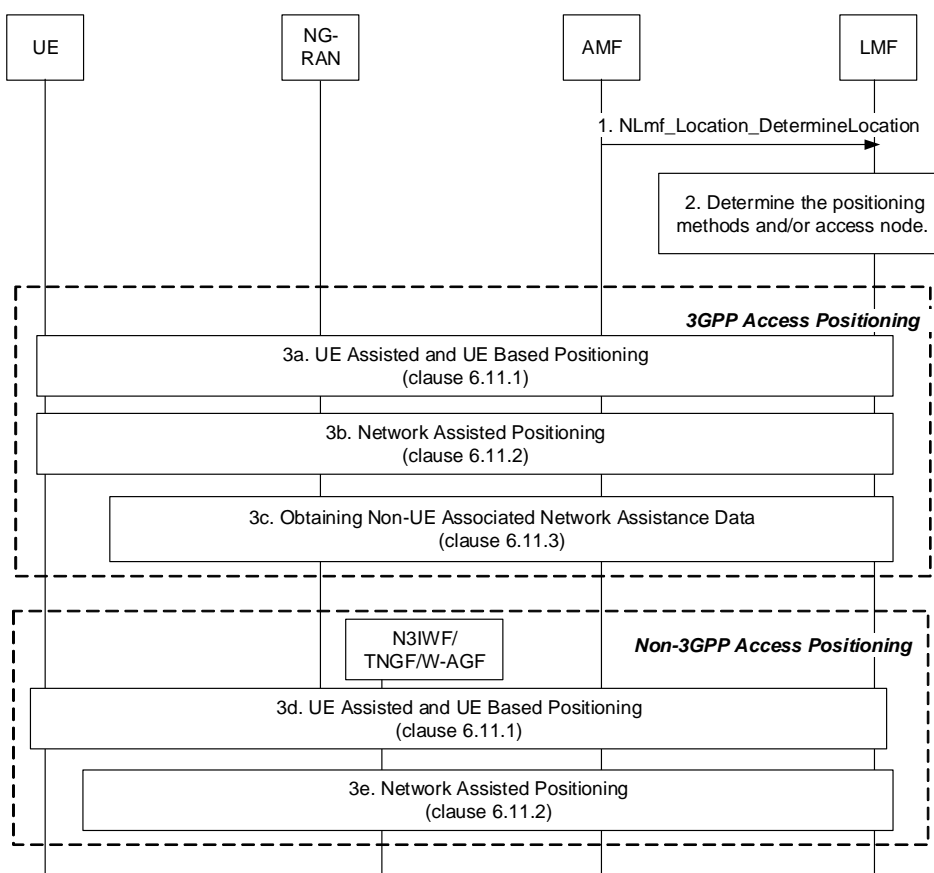


Figure 6.9.1-1: Common positioning procedures when UE is served by the one PLMN

1. The AMF invokes the Nlmf_Location_DetermineLocation service operation towards the LMF to request the current location of the UE, which includes the QoS requirement and UE connectivity state per access type.
2. The LMF determines the positioning access type and the positioning method based on the UE/network positioning capability, the QoS requirement and UE connectivity state per access type received from the AMF and the locally configured operator policy. The LMF may also determine the access type for transmission of an LPP message to the UE (e.g. in order to ensure the UE will be in a connected state for the selected positioning access type).

When the LPP protocol in TS 36.355 [20] is determined to be used to obtain location information from the UE and the UE has both 3GPP and non-3GPP access, the AMF shall decide which access type should be used to transmit the location information if the LMF did not select an access type. For example, if the UE is in CM-IDLE state in 3GPP access and in CM-CONNECTED state in Non-3GPP access, AMF may prefer to select the N3IWF/TNGF/W-AGF to relay positioning signalling to UE, rather than performing paging procedures via the 3GPP access.

When the NRPPa protocol in TS 38.455 [15] is determined to be used to obtain location information from the NG-RAN or N3IWF/TNGF/W-AGF:

- In the case that 3GPP Access is determined to be used to transmit the location information, the Network Assisted Positioning procedure in step 3b and/or the obtaining Non-UE Associated Network Assistance Data procedure in step 3c shall be performed.
- In the case that non-3GPP Access is determined to be used to obtain the location information, the Network Assisted Positioning procedure in step 3e shall be performed.

When the LPP protocol in TS 36.355 [20] is determined to be used to obtain location information from the UE:

- In the case that 3GPP Access is determined to be used to relay the location information, the UE Assisted and UE Based Positioning procedure in step 3a shall be performed.

- In the case that non-3GPP Access is determined to be used to relay the location information, the UE Assisted and UE Based Positioning procedure in step 3d shall be performed.
- 3a. This step is same as the UE Assisted and UE Based Positioning procedure in clause 6.11.1.
- 3b. This step is same as the Network Assisted Positioning procedure in clause 6.11.2 with the difference that step 1 of clause 6.11.2 includes the selected Access Type (i.e. 3GPP access). The AMF forwards the Network Positioning message to the NG-RAN in step 3 of clause 6.11.2 based on the received Access Type.
- 3c. This step is same as the Obtaining Non-UE Associated Network Assistance Data procedure in clause 6.11.3.
- 3d. This step is same as the UE Assisted and UE Based Positioning procedure in clause 6.11.1 with the following difference:
- The NG-RAN in clause 6.11.1 is replaced by the N3IWF/TNGF/W-AGF in Figure 6.9.1-1;
 - Steps 2 and 5 in clause 6.11.1 are omitted;
 - The location information returned by the UE can include information specified in clause 5.3.1.
- 3e. This step is same as the Network Assisted Positioning procedure in clause 6.11.2 with the following difference:
- The NG-RAN in clause 6.11.2 is replaced by the N3IWF/TNGF/W-AGF in Figure 6.9.1-1;
 - Steps 2 and 4 in clause 6.11.2 are omitted;
 - The Access Type, i.e. non-3GPP access type, which is selected to provide the location information is included in step 1 of clause 6.11.2. The AMF forwards the Network Positioning message to the N3IWF/TNGF/W-AGF based on the received Access Type in step 1 of clause 6.11.2.
 - The location information returned in step 5 of clause 6.11.2 is specified in clause 5.3.1.

The UE is replaced by 5G-RG in the case of wireline access type.

6.9.2 MT-LR Procedures when a UE is served by Different PLMNs for 3GPP Access and Non-3GPP Access

Figure 6.9.2-1 and Figure 6.9.2-2 show the enhanced MT-LR positioning procedures to support location service with non-3GPP access when the UE is served by different PLMNs for 3GPP access and non-3GPP access. The procedures can be triggered by the 5GC-MT-LR Procedures described in clause 6.1.1, clause 6.1.2 and clause 6.3, which are applicable to a request from an LCS client for an immediate current location or a deferred location.

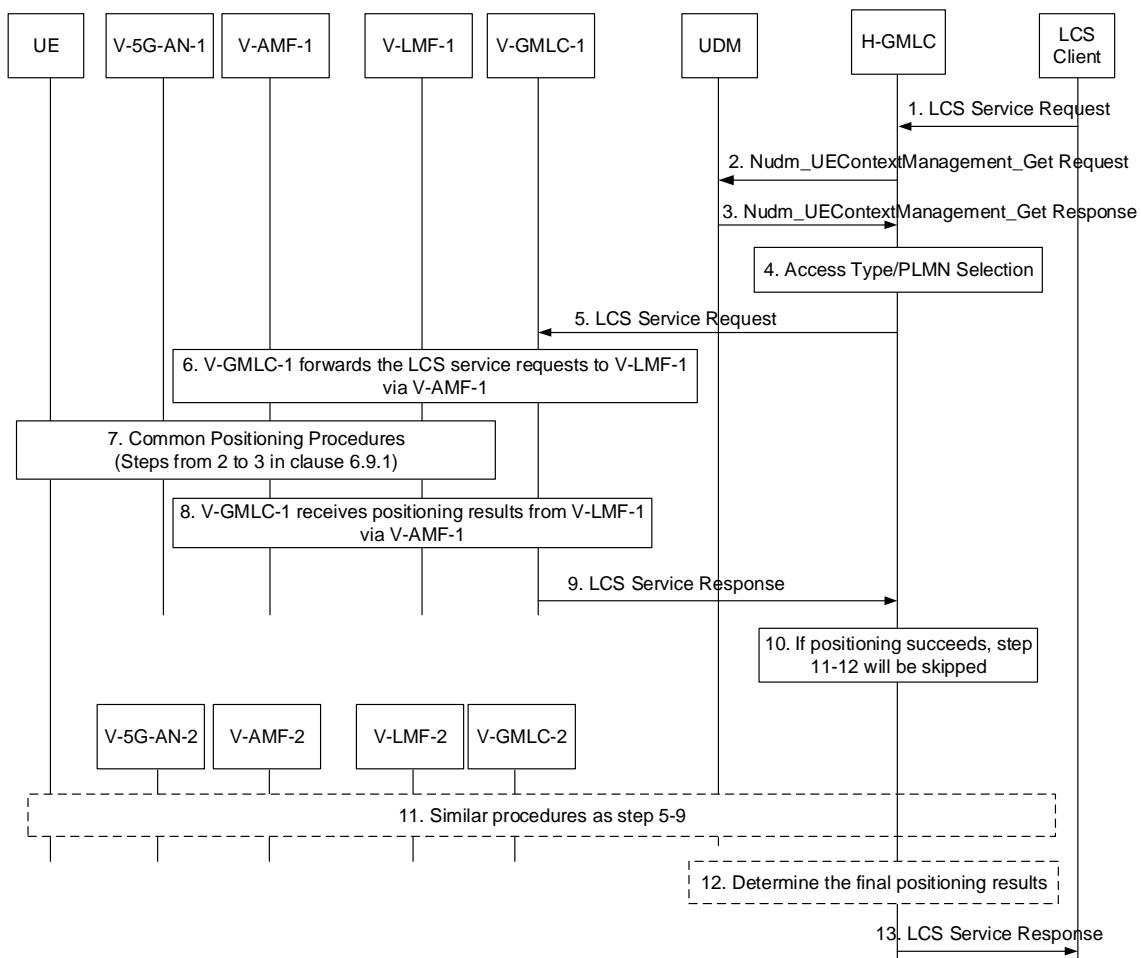


Figure 6.9.2-1: MT-LR positioning procedures when UE is served by the two VPLMNs

1. The step is same as step 1 in clause 6.1.1 or clause 6.3.1.
2. The step is same as step 2 in clause 6.1.1 or clause 6.3.1.
3. The step is same as step 3 in clause 6.1.1 or clause 6.3.1 with the difference that when the UE is served by more than one AMF the UDM provides to the HGMLC for each access type,
 - serving AMF identity with the corresponding PLMN Id,
 - possibly a VGMLC address.
4. When the HGMLC identifies that the UE is served by different PLMNs according to the returned information from the UDM in step 3 it may retrieve the CM state(s) per Access Type from the candidate AMFs by using Namf_EventExposure service, or from the UDM using Nudm_EventExposure service. The HGMLC selects one access type and its associated AMF based on the UDM returned information in step 3, QoS requirement, CM state(s) per Access type of the UE, PLMN identity and/or the locally configured operator policy.

NOTE: The locally configured operator policy in the HGMLC can include access type and CM state and PLMN priority for positioning. For example, the local policy can be 3GPP access first and/or connected state first and/or V-PLMN and/or H-PLMN first.

5. The HGMLC forwards the location request to the VGMLC-1 and may include the V-AMF-1 identity received in step 3 and the target UE identity (e.g. SUPI).
6. The VGMLC-1 invokes the Namf_Location_ProvideLocation_Request service operation to forward the location request to the V-AMF-1. Then the V-LMF-1 receives the location request from the V-AMF-1.
7. This step is same as step 2-3 of the Common Positioning Procedures in clause 6.9.1.

- 8-9. The VGMLC-1 receive the location service response from the V-LMF-1 and for a request for an immediate location, returns positioning results to the HGMLC. For an immediate location, the location service response contains positioning information, the information about the positioning method used and the indication of whether the obtained location estimate satisfies the requested LCS QoS (e.g. accuracy) or not (described in TS 23.271 [4] clause 9.1.1). For a request for a deferred location, the location service response indicates whether the location request was accepted.
- 10. For a request for an immediate location, if the HGMLC identifies that the location service response from the chosen PLMN meets required LCS QoS, it returns the results to the LCS Client directly. Otherwise, the HGMLC may forward the location request to another AMF (in another PLMN) so as to obtain the positioning result which can meet required LCS QoS shown as step 11. For a request for a deferred location, if the HGMLC identifies that location service was accepted (by the chosen PLMN), it returns this indication to the LCS Client directly. Otherwise, the HGMLC may forward the location request to another AMF (in another PLMN).
- 11. This step obtains the immediate positioning information or requests a deferred location from another PLMN, the details are the same as steps 5-9.
- 12-13. The HGMLC returns a location service response to the LCS client. For a request for immediate location, if the positioning result from the other PLMN meets the QoS requirement, the HGMLC returns it to the LCS client. Otherwise, the HGMLC returns final location service response without including any positioning result. For a request for deferred location, if the result from the other PLMN indicates acceptance of the location request, the HGMLC returns this to the LCS client. Otherwise, the HGMLC returns a final location service response indicating failure of the deferred location request.

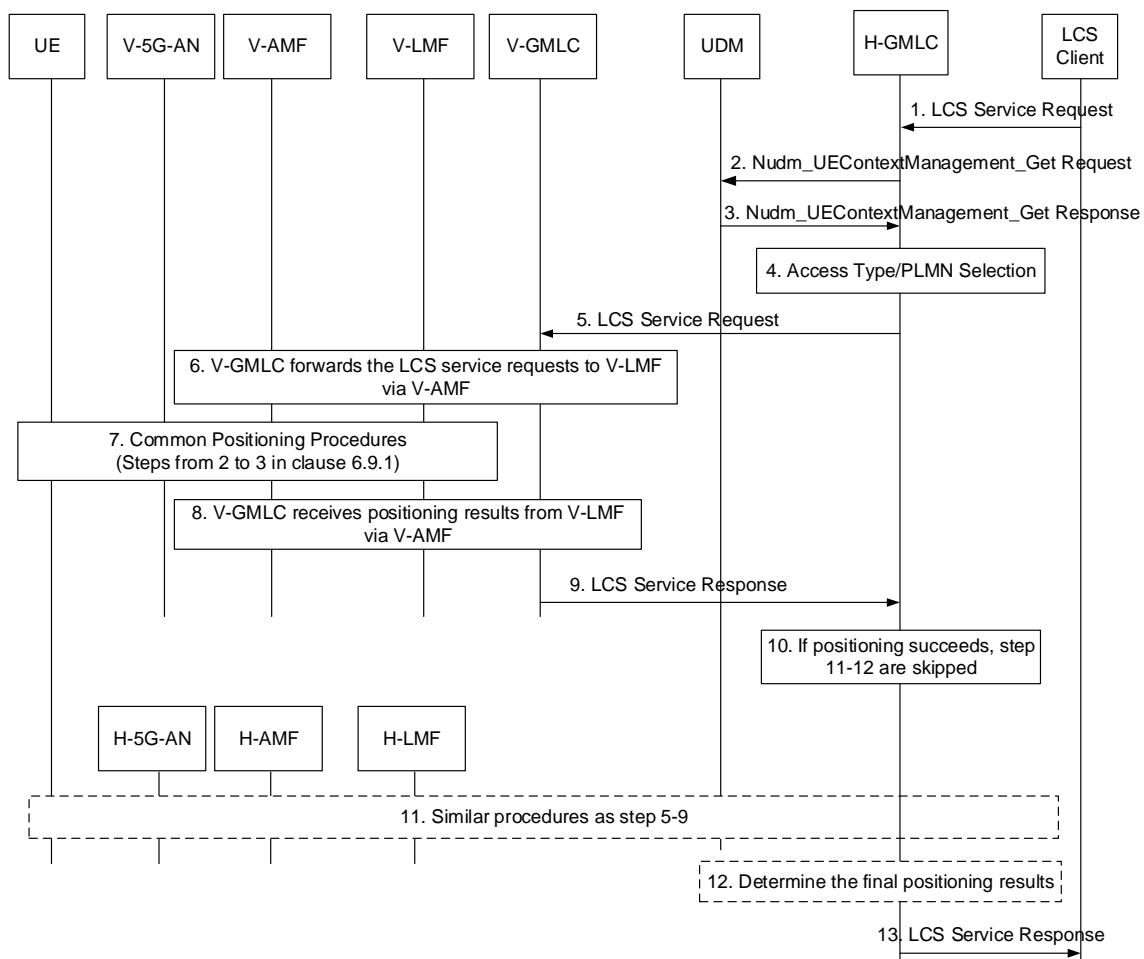


Figure 6.9.2-2: MT-LR positioning procedures when UE is served by HPLMN and VPLMN

Figure 6.9.2-2 shows the MT-LR positioning procedures when the UE is served by the H-PLMN and a V-PLMN. The difference with procedures shown in Figure 6.9.2-1 is that the HGMLC interacts with AMF directly shown in step 11 of Figure 6.9.2-2 without involving VGMLC shown in step 11 of Figure 6.9.2-1. In scenarios where the HGMLC

prioritizes location by the H-PLMN rather than V-PLMN at step 4, steps 5-9 may be replaced by step 11 and step 11 (when step 11 occurs) is then replaced by steps 5-9.

6.9.3 MO-LR Procedures when UE is served by the Different PLMNs via 3GPP Access and Non-3GPP Access

When UE is served by the different PLMNs via 3GPP access and Non-3GPP access, UE uses the UE Local Configuration to select the access to initiate MO-LR procedure which is the same as the 5GC-MO-LR Procedure in clause 6.2. If Non-3GPP access is selected, the following difference exists:

- The NG-RAN in 5GC-MO-LR Procedure in clause 6.2 is corresponding to the N3IWF/TNGF;
- Step 5 in 5GC-MO-LR Procedure in clause 6.2 is the same as step 3d or 3e in Common Positioning Procedure when UE is served by the same PLMN in clause 6.9.1.

6.9.4 NI-LR Procedures when a UE is served by Different PLMNs for 3GPP access and non-3GPP access

When UE is served by the different PLMNs via 3GPP access and non-3GPP access, the UE selects one access to register to the 5GC for emergency services as defined in TS 23.167 [10], or request the establishment of a PDU Session related to an emergency session.

The NI-LR procedures are the same as the 5GC-NI-LR Procedure (described in clause 6.10.1) with the difference that:

- if the procedures are performed for non-3GPP access, NG-RAN in Figure 6.10.1 is replaced by an N3IWF/TNGF/W-AGF and the UE Positioning in step 3 in Figure 6.10.1 is performed according to steps 3d and 3e in Figure 6.9.1-1.
- In step 2 in 5GC-NI-LR Procedure in clause 6.10.1, AMF also provides access type to LMF. LMF shall use the access type provided by AMF for positioning.

The UE is replaced by 5G-RG in the case of wireline access type.

6.10 Procedures dedicated to Support Regulatory services

6.10.1 5GC-NI-LR Procedure

Figure 6.10.1-1 shows a Network Induced Location Request (NI-LR) procedure for a UE in the case where the UE initiates an emergency session or other session using NG-RAN. The procedure assumes that the serving AMF is aware of the regulatory service associated with the session (e.g. emergency session initiation - e.g. due to supporting an Emergency Registration procedure or assisting in establishing an emergency PDU Session).

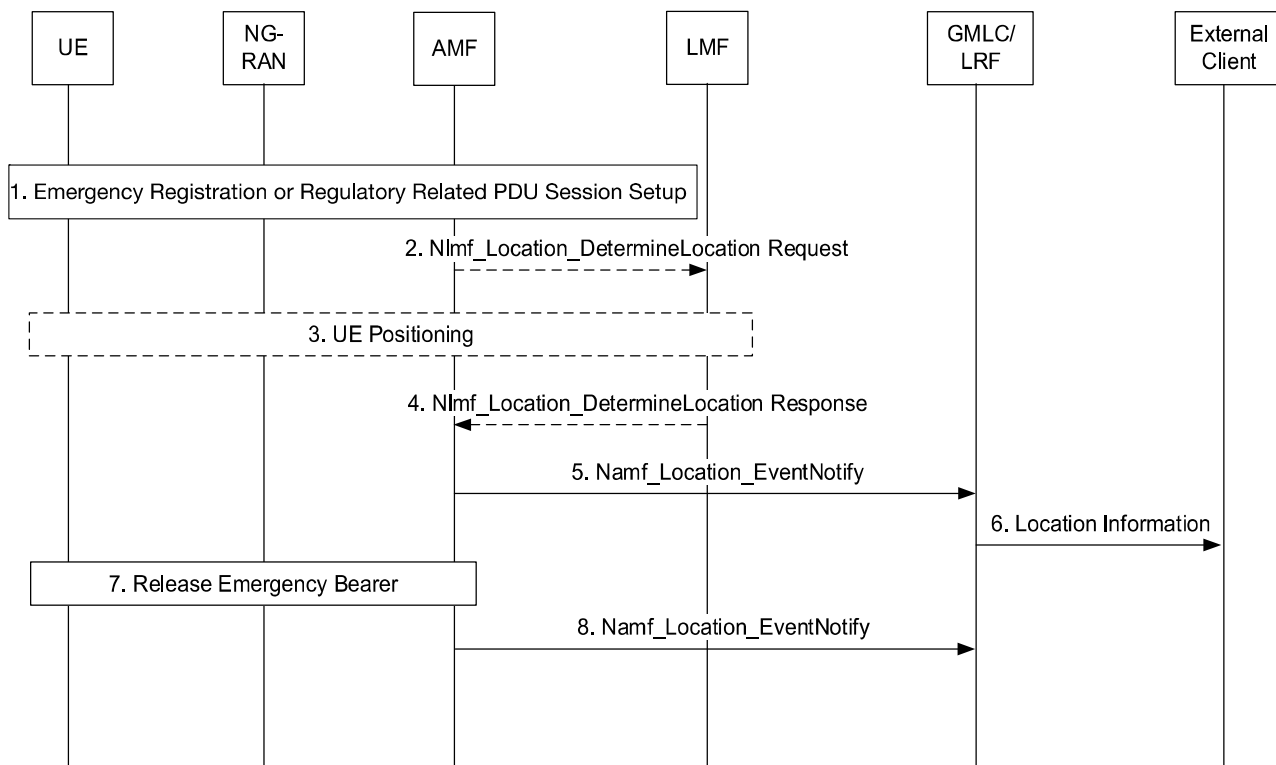


Figure 6.10.1-1: 5GC Network Induced Location Request (5GC-NI-LR) for a UE

1. The UE registers to the 5GC for emergency services or requests the establishment of a PDU Session related to an applicable regulatory service (e.g., emergency session initiation).
2. The AMF may select an LMF based on NRF query or configuration in AMF and invoke the `Nlmf_Location_DetermineLocation` service operation towards the LMF to request the current location of the UE. The service operation includes a LCS Correlation identifier, the serving cell identity of the Primary Cell in the Master RAN node and the Primary Cell in the Secondary RAN node when available based on Dual Connectivity scenarios, and an indication of a location request from a regulatory services client (e.g., emergency services) and may include an indication if UE supports LPP, the required QoS and Supported GAD shapes. If any of the procedures in clause 6.11.1 or 6.11.2 are used the service operation includes the AMF identity.

3. If step 2 occurs, the LMF performs one or more of the positioning procedures described in clause 6.11.1, 6.11.2 and 6.11.3.

4. If step 3 occurs, the LMF returns the `Nlmf_Location_DetermineLocation Response` towards the AMF to return the current location of the UE. The service operation includes the LCS Correlation identifier, the location estimate, its age and accuracy and may include information about the positioning method.

NOTE 1: Any remaining procedures for regulatory services other than emergency services are not addressed in this flow. The remaining steps are applicable for emergency services.

5. For emergency services, the AMF selects a GMLC based on NRF query or configuration in AMF. The information regarding the endpoint in the GMLC to deliver the event notification, is obtained from the NRF as specified in clause 7.1.2 of TS 23.501 [18] or from local configuration in the AMF. AMF invokes the `Namf_Location_EventNotify` service operation towards the selected GMLC to notify the GMLC of an emergency session initiation. The service operation includes the SUPI or the PEI, and the GPSI if available, the identity of the AMF, an indication of an emergency session and any location obtained in step 3.

6. For emergency services, the GMLC forwards the location to an external emergency services client or may wait for a request for the location from the external emergency services client (not shown in Figure 6.10.1-1) before forwarding the location.

7. For emergency services, the emergency services session and emergency PDU Session are released.

- For emergency services, the AMF invokes the `Namf_Location_EventNotify` service operation towards the GMLC to notify the GMLC that the emergency session was released to enable the GMLC and LRF to release any resources associated with the emergency session.

6.10.2 5GC-MT-LR Procedure without UDM Query

Figure 6.10.2-1 illustrates a location request for an emergency services session, where an emergency services client (e.g. a Public Safety Answering Point) identifies the target UE and the serving LRF using correlation information that was previously provided to it by the IMS Core. The signalling used to provide the correlation information to the PSAP is defined in TS 23.167 [10]. The correlation information may be used by the LRF to retrieve other information previously provided to it by the IMS Core and/or AMF as described for Figure 6.10.1-1. This allows the GMLC associated with the LRF to request a location from the AMF without needing to query the UDM of the target UE for the serving AMF address. This scenario therefore supports location of emergency sessions from roamers and USIM-less and other non-registered UEs, and requires that identifying information for the UE and AMF have been provided to the GMLC/LRF as described in clauses 6.10.1 and 6.10.3.

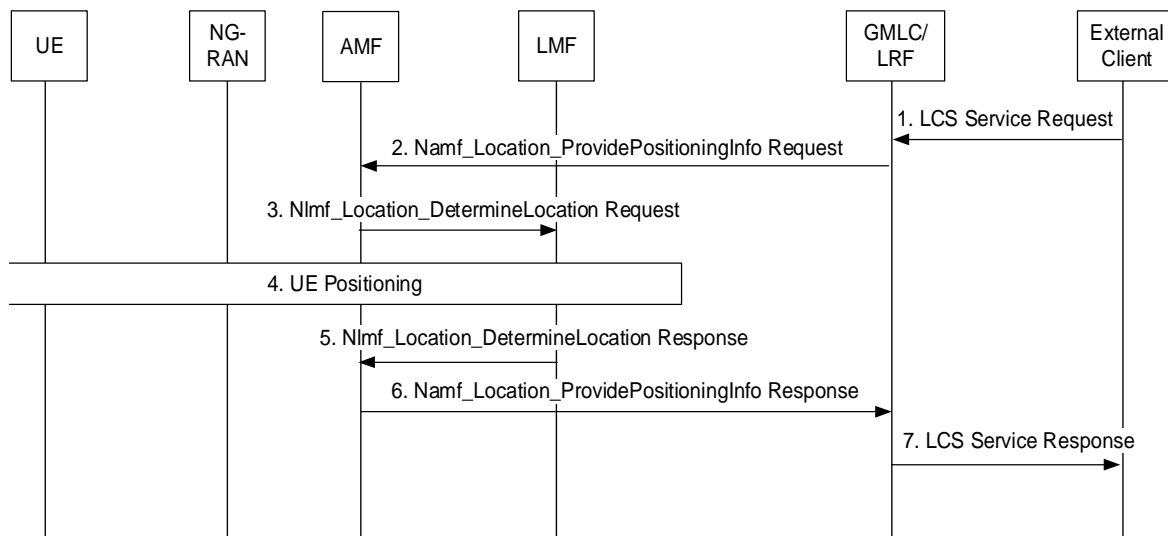


Figure 6.10.2-1: 5GC-MT-LR Procedure without UDM Query

- The external emergency services client (e.g. a PSAP) sends a request to the LRF for a location for the target UE and includes correlation information identifying the target UE. The request may include the required QoS and Supported GAD shapes. The LRF address and the correlation information would have been previously provided to the external client when the emergency session from the UE was established.
- The LRF/GMLC determines the AMF by associating the correlation information received from the external client with other information received previously from the LMF as described in clauses 6.10.1 and 6.10.3. The GMLC invokes the `Namf_Location_ProvidePositioningInfo` service operation towards the AMF to request the current location of the UE. The service operation includes the SUPI or the PEI and an indication of a location request from an emergency services client and may include the required QoS and Supported GAD shapes. The AMF identifies the target UE using the SUPI or in the case of a USIM-less emergency session, or non-registered USIM emergency session, the PEI.
- The AMF selects an LMF based on NRF query or configuration in AMF and invokes the `Nlmf_Location_DetermineLocation` service operation towards the LMF to request the current location of the UE. The service operation includes a LCS Correlation identifier, the serving cell identity and an indication of a location request from an emergency services client and may include an indication if UE supports LPP, the required QoS and Supported GAD shapes. If any of the procedures in clause 6.11.1 or clause 6.11.2 are used the service operation includes the AMF identity.
- The LMF performs one or more of the positioning procedures described in clauses 6.11.1, 6.11.2 and 6.11.3.
- The LMF returns the `Nlmf_Location_DetermineLocation Response` towards the AMF to return the current location of the UE. The service operation includes the location estimate, its age and accuracy and may include information about the positioning method.

6. The AMF returns the Namf_Location_ProvidePositioningInfo Response towards the GMLC/LRF to return the current location of the UE. The service operation includes the LCS Correlation identifier, the location estimate, its age and accuracy and may include information about the positioning method.
7. The LRF sends the location service response to the external emergency services client.

6.10.3 Location continuity for Handover of an Emergency session from NG-RAN

Figure 6.10.3-1 shows support for location continuity for handover of an emergency session from NG-RAN on the source side to either NG-RAN or another 3GPP RAN on the target side. The procedure applies when control plane location according to Figures 6.10.1-1 and 6.10.2-1 is used for location of the UE on the source side. The procedure is based on the procedures for location continuity currently defined in TS 23.271 [4] clause 9.4.5.4.

NOTE: If User Plane (SUPL) Location Protocol [bb] is used on the source (NG-RAN) side, then the current procedure for location continuity in TS 23.271 [4] can be used.

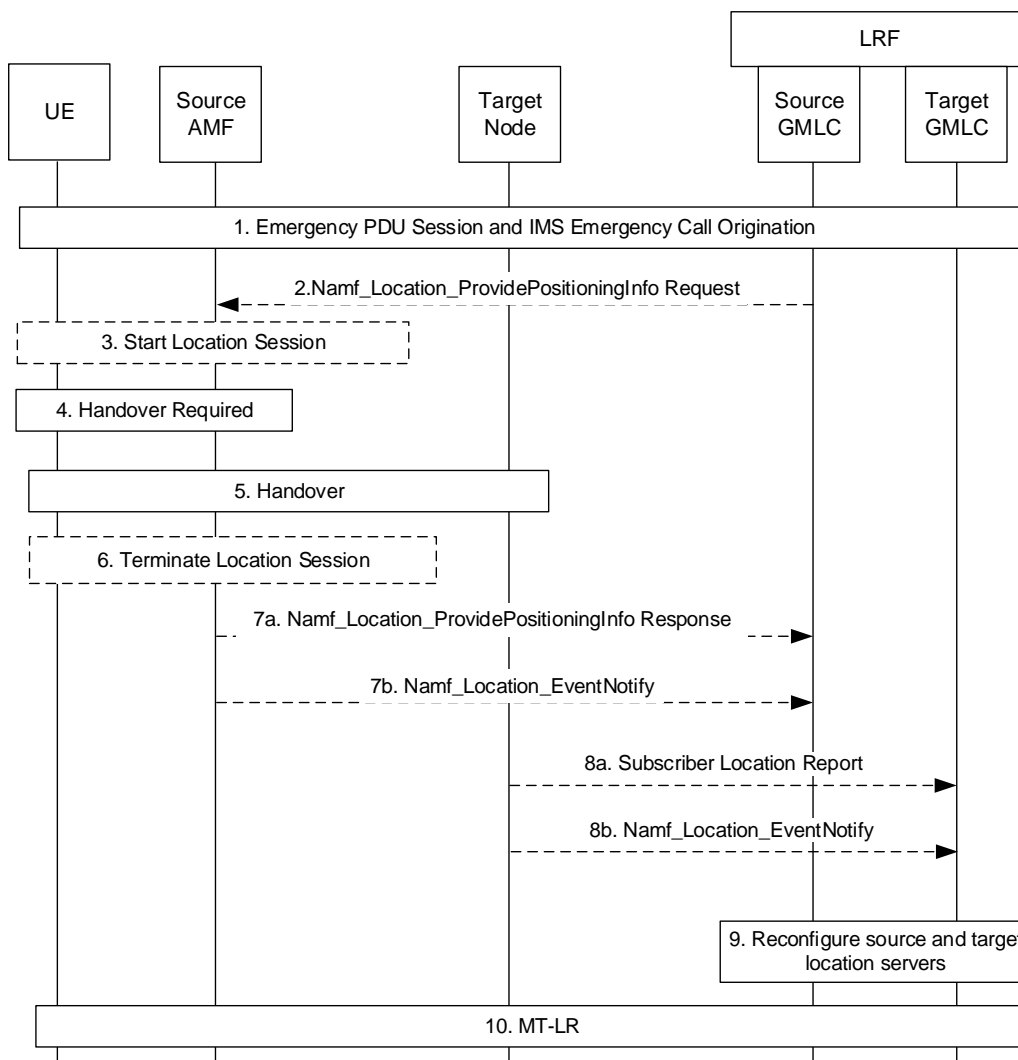


Figure 6.10.3-1: Location Continuity for Handover of an Emergency session from NG-RAN

1. Following the request for an emergency session, the UE establishes a PDU Session for emergency services and an IMS emergency session for NG-RAN access, during which an LRF is assigned in the serving network IMS and a source GMLC may be chosen. The 5GC-NI-LR procedure of Figure 6.10.1-1 is also performed which provides the source AMF identity to the GMLC and LRF and optionally an initial location for the UE.

2. At some later time, the LRF may need the UE location and requests the source GMLC to invoke the `Namf_Location_ProvidePositioningInfo` service operation towards the AMF to request the current location of the UE. The service operation includes the SUPI or the PEI, the required QoS and an indication of a location request from an emergency services client.
3. If step 2 occurs or if support for an NI-LR is required, the source AMF starts a location session to obtain the location of the UE as described in clause 6.10.2 or clause 6.10.1.
4. The source AMF receives a request to handover the UE to a cell associated with a different target node which may be another AMF for intra-RAN handover or a different type of node (e.g. an MME) for inter-RAN handover (e.g. to E-UTRAN connected to EPC).
5. The handover procedure is executed as specified in clause 4.9.1.3 of TS 23.502 [19].
6. Any location session started in step 3 may terminate normally before step 6. If not, the source AMF shall abort the location session once step 5 is complete.
- 7a. If steps 2 and 3 has occurred, the source AMF returns the `Namf_Location_ProvidePositioningInfo` Response towards the GMLC to return any location estimate obtained for the UE. The service operation includes the target node identity.
- 7b. If steps 2 and 7a do not occur, the source AMF may invoke the `Namf_Location_EventNotify` service operation towards the source GMLC (i.e. the GMLC used in step 1) to indicate the handover. The service operation includes the SUPI or the PEI and the GPSI if available, an event type indicating handover and the identity of the target node.
- 8a. For inter-RAN handover (e.g. to E-UTRAN connected to EPC) and if control plane location will be used on the target side, the target node (e.g. MME) may send a Subscriber Location Report to a GMLC on the target side after completion of the handover in step 6. The Subscriber Location Report carries the UE identity (IMSI, MSISDN and/or IMEI), an event type indicating handover and the identity of the target node. The target node may determine the target GMLC from configuration information.
- 8b. For intra-RAN handover and if control plane location will be used on the target side, the target AMF may invoke the `Namf_Location_EventNotify` service operation towards the GMLC to indicate the handover. The service operation includes the SUPI or the PEI and the GPSI if available, an event type indicating handover and the identity of the target node.
9. Reconfiguration of the LRF and the source and target GMLCs may occur in a manner outside the scope of 3GPP.
10. If the LRF needs a location estimate for the UE after handover has occurred and if control plane location is used on the target side, the LRF may instigate an MT-LR request via the target Node.

6.11 Common Sub-Procedures

6.11.1 UE Assisted and UE Based Positioning Procedure

Figure 6.11.1-1 shows a positioning procedure used by an LMF to support UE based positioning, UE assisted positioning and delivery of assistance data. The procedure is based on use of the LPP protocol defined in TS 36.355 [20] between the LMF and UE.

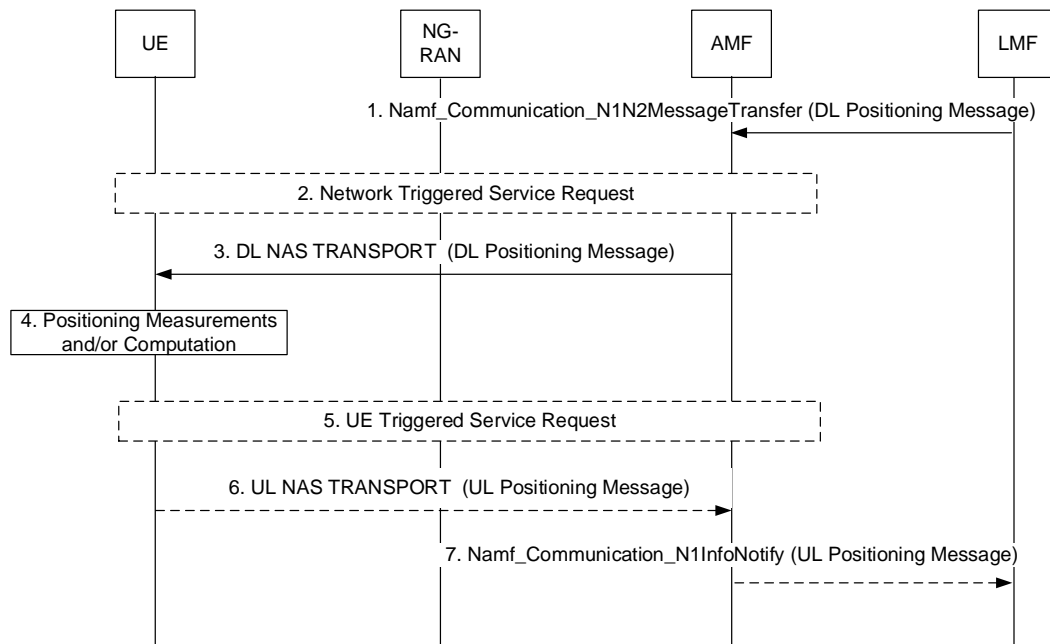


Figure 6.11.1-1: UE Assisted and UE Based Positioning Procedure

Precondition: A LCS Correlation identifier and the AMF identity has been passed to the LMF by the serving AMF.

1. The LMF invokes the `Namf_Communication_N1N2MessageTransfer` service operation towards the AMF to request the transfer of a Downlink (DL) Positioning message to the UE. The service operation includes the DL Positioning message. The Session ID parameter of the `Namf_Communication_N1N2MessageTransfer` service operation is set to the LCS Correlation identifier. The Downlink Positioning message may request location information from the UE, provide assistance data to the UE or query for the UE capabilities.
2. If the UE is in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19] to establish a signalling connection with the UE.
3. The AMF forwards the Downlink Positioning message to the UE in a DL NAS TRANSPORT message. The AMF includes a Routing identifier, in the DL NAS TRANSPORT message, which is set to the LCS Correlation identifier. The Downlink Positioning message may request the UE to respond to the network, e.g. may request the UE to acknowledge the Downlink Positioning message, to return location information or to return capabilities, as defined in TS 36.355 [20].
4. The UE stores any assistance data provided in the Downlink Positioning message and performs any positioning measurements and/or location computation requested by the Downlink Positioning message.
5. If the UE has entered CM-IDLE state during step 4 and needs to responses to the request received in step 3, the UE instigates the UE triggered Service Request as defined in clause 4.2.3.2 of TS 23.502 [19] in order to establish a signalling connection with the AMF.
6. [Conditional] The UE sends to the AMF the Uplink Positioning message included in a NAS TRANSPORT message, e.g. to acknowledge the Downlink Positioning message, to return any location information obtained in step 4 or returns any capabilities, as requested in step 3. When the UE sends Uplink Positioning message in a NAS TRANSPORT message, the UE shall also include in the UL NAS TRANSPORT message the Routing identifier received in step 3.
7. [Conditional] The AMF invokes the `Namf_Communication_N1MessageNotify` service operation towards the LMF indicated by the routing identifier received in step 6. The service operation includes the Uplink Positioning message received in step 6 and the LCS Correlation identifier. Steps 6 and 7 may be repeated if the UE needs to send multiple Uplink Positioning messages to respond to the request received in Step 3. Steps 1 to 7 may be repeated to send new assistance data, and to request further location information and further UE capabilities.

6.11.2 Network Assisted Positioning Procedure

Figure 6.11.2-1 shows a procedure that may be used by an LMF to support network assisted and network based positioning. The procedure may be based on an NRPPa protocol in TS 38.455 [15] between the LMF and NG-RAN.

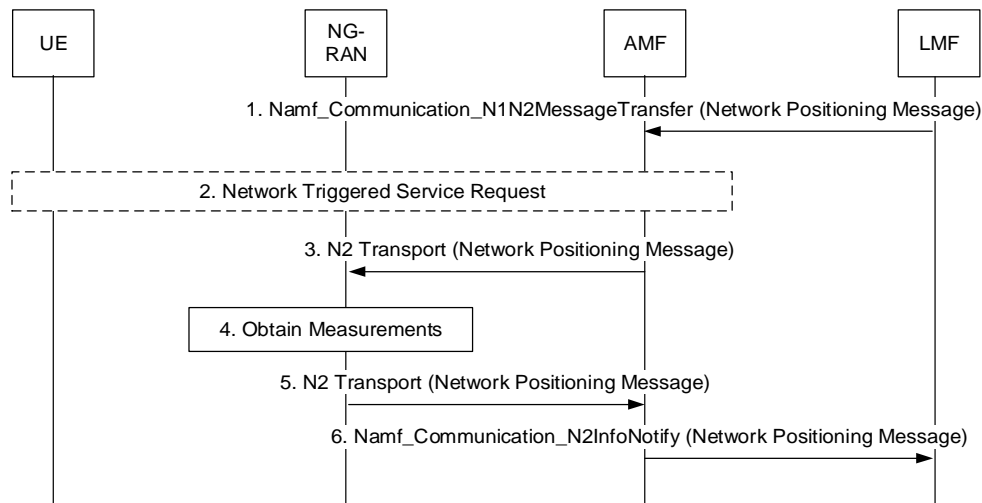


Figure 6.11.2-1: Network Assisted Positioning Procedure

Precondition: A LCS Correlation identifier and the AMF identity have been passed to the LMF by the serving AMF.

1. The LMF invokes the `Namf_Communication_N1N2MessageTransfer` service operation towards the AMF to request the transfer of a Network Positioning message to the serving NG-RAN node (gNB or ng-eNB) for the UE. The service operation includes the Network Positioning message and the LCS Correlation identifier. The Network Positioning message may request location information for the UE from the NG-RAN.
2. If the UE is in CM IDLE state, the AMF initiates a network triggered Service Request procedure as defined in clause 4.2.3.3 of TS 23.502 [19], to establish a signalling connection with the UE.
3. The AMF forwards the Network Positioning message to the serving NG-RAN node in an N2 Transport message. The AMF includes a Routing identifier, in the N2 Transport message, identifying the LMF (e.g. a global address of the LMF).
4. The serving NG-RAN node obtains any location information for the UE requested in step 3.
5. The serving NG-RAN node returns any location information obtained in step 4 to the AMF in a Network Positioning message included in an N2 Transport message. The serving NG-RAN node shall also include the Routing identifier in the N2 Transport message received in step 3.
6. The AMF invokes the `Namf_Communication_N2InfoNotify` service towards the LMF indicated by the routing identifier received in step 5. The service operation includes the Network Positioning message received in step 5 and the LCS Correlation identifier. Steps 1 to 6 may be repeated to request further location information and further NG-RAN capabilities.

6.11.3 Obtaining Non-UE Associated Network Assistance Data

Figure 6.11.3-1 shows a procedure which may be used by an LMF to support network assisted and network based positioning. This procedure is not associated with a UE location session. It is used to obtain network assistance data from a NG-RAN node (e.g. gNB or ng-eNB). The procedure may be based on an NRPPa protocol in TS 38.455 [15] between the LMF and NG-RAN.

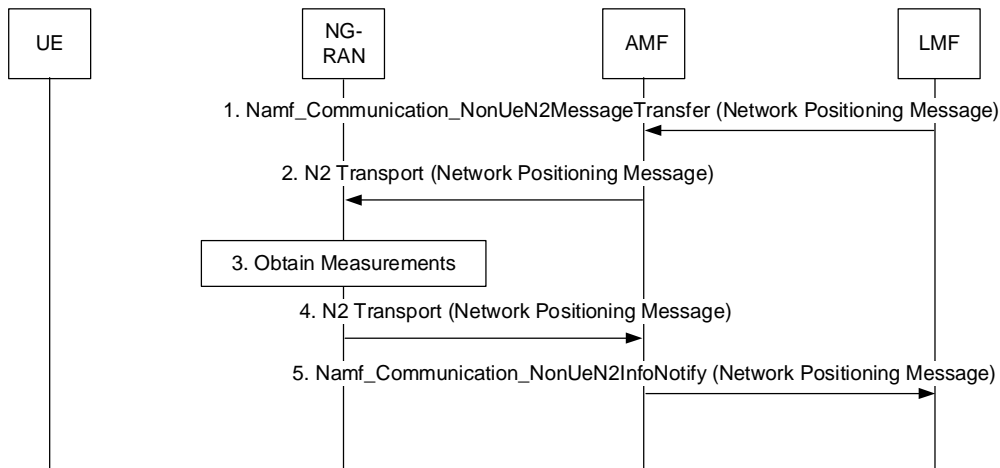


Figure 6.11.3-1: Procedure for Obtaining Non-UE Associated Network Assistance Data

1. The LMF invokes the `Namf_Communication_NonUeN2MessageTransfer` service operation towards the AMF to request the transfer of a Network Positioning message to a NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the Network Positioning message and the target NG-RAN node identity. The Network Positioning message may request position related information from the NG-RAN.
2. The AMF forwards the Network Positioning message to the target NG-RAN node indicated in step 1 in an N2 Transport message. The AMF includes a Routing identifier, in the N2 Transport message, identifying the LMF.
3. The target NG-RAN node obtains any position related information requested in step 2.
4. The target NG-RAN node returns any position related information obtained in step 3 to the AMF in a Network Positioning message included in an N2 Transport message. The target NG-RAN node shall also include the Routing identifier in the N2 Transport message received in step 2.
5. The AMF invokes the `Namf_Communication_NonUeN2InfoNotify` service operation towards the LMF indicated by the routing identifier received in step 4. The service operation includes the Network Positioning message received in step 4. Steps 1 to 5 may be repeated to request further position related information from the NG-RAN.

6.12 UE Location Privacy Setting Procedure

6.12.1 UE Location Privacy Setting Procedure Initiated by UE

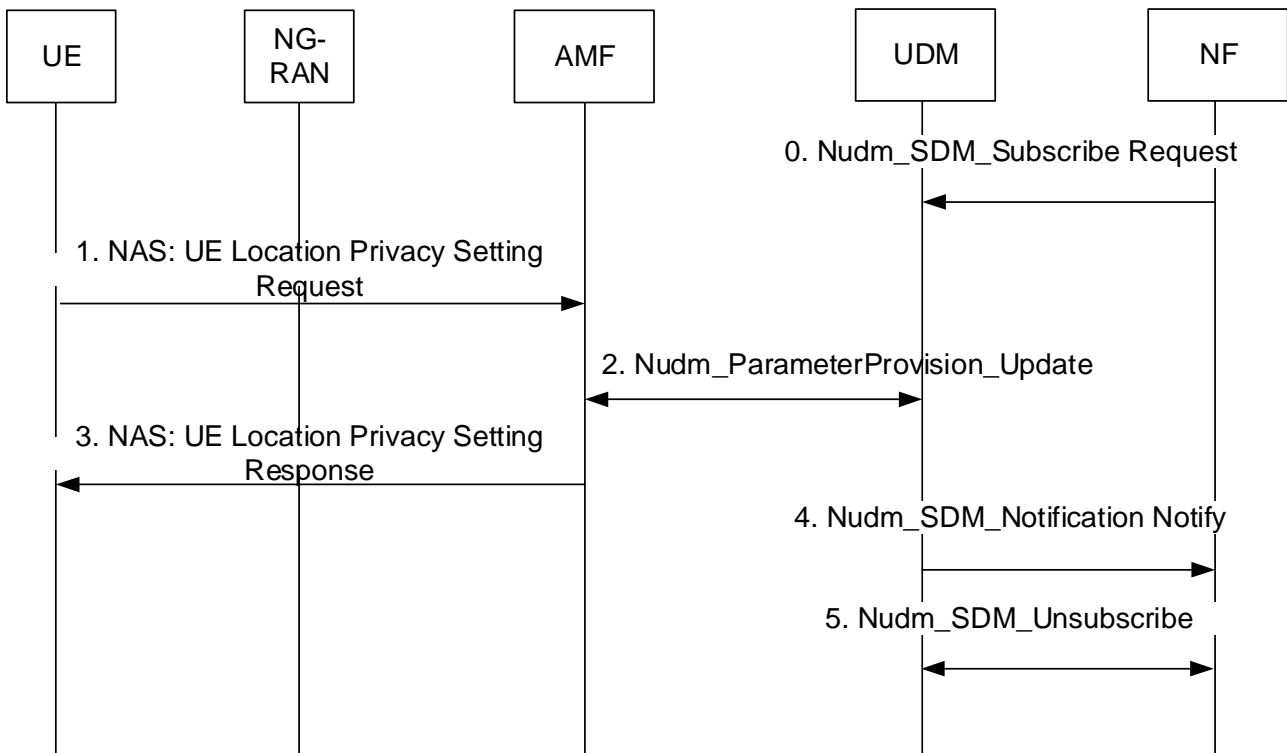


Figure 6.12.1-1: UE Location Privacy Setting procedure initiated by UE

0. NF (e.g. GMLC, NEF) may subscribe to UDM notifications of UE LCS privacy profile updates.

NOTE: NF can decide to subscribe to such notifications while a deferred location request is on-going.

1. If the UE has generated or updated the UE Location Privacy Indication, the UE sends the Location Privacy Indication to the AMF via UE Location Privacy Setting Request in N1 NAS message. The UE Location Privacy Indication indicates whether allows or disallows the subsequent LCS requests for the UE, as defined in clause 5.4.
2. The AMF invokes a Nudm_ParameterProvision_Update (LCS privacy) service operation towards the UDM and the service operation carries the Location Privacy Indication information. The UDM stores or updates the UE LCS privacy profile in the UDR by invoking a Nudr_DM_Update (SUPI, Subscription Data) service operation accordingly.
3. The AMF responses to the UE via UE Location Privacy Setting Response in N1 NAS message.
4. UDM notifies the subscribed Network Function (e.g. GMLC, NEF) of the updated UE LCS privacy profile via Nudm_SDM_Notification Notify message.
5. NF (e.g. GMLC, NEF) may unsubscribe to UDM notifications of UE LCS privacy profile updates e.g. if a deferred location procedure is cancelled.

6.12.2 UE Location Privacy Setting Procedure Initiated by AF

The procedure is defined by using the procedure in clause 4.15.6.2 of TS 23.502 [19] to set the Location Privacy Indication parameters and should in addition unsubscribe to UDM notifications of UE LCS privacy profile updates e.g. if a deferred location procedure is cancelled.

6.13 Procedures with interaction between 5GC and EPC

6.13.1 MT-LR Procedure

Figure 6.13.1-1 illustrates network positioning requested by the LCS clients or the AF external to the PLMN for the case where the LCS Client or AF is associated with a GMLC in 5GC domain and the UE is served by the EPC domain. Both non-roaming and roaming scenarios are described. For non-roaming scenario both the case of separate EPC GMLC and 5GC GMLC connected with Lr reference point and the case with combined 5GC GMLC and EPC GMLC are described. For roaming scenario, the 5GC GMLC in the HPLMN uses NL3 to interconnect with the combined 5GC+EPCGMLC in the VPLMN.

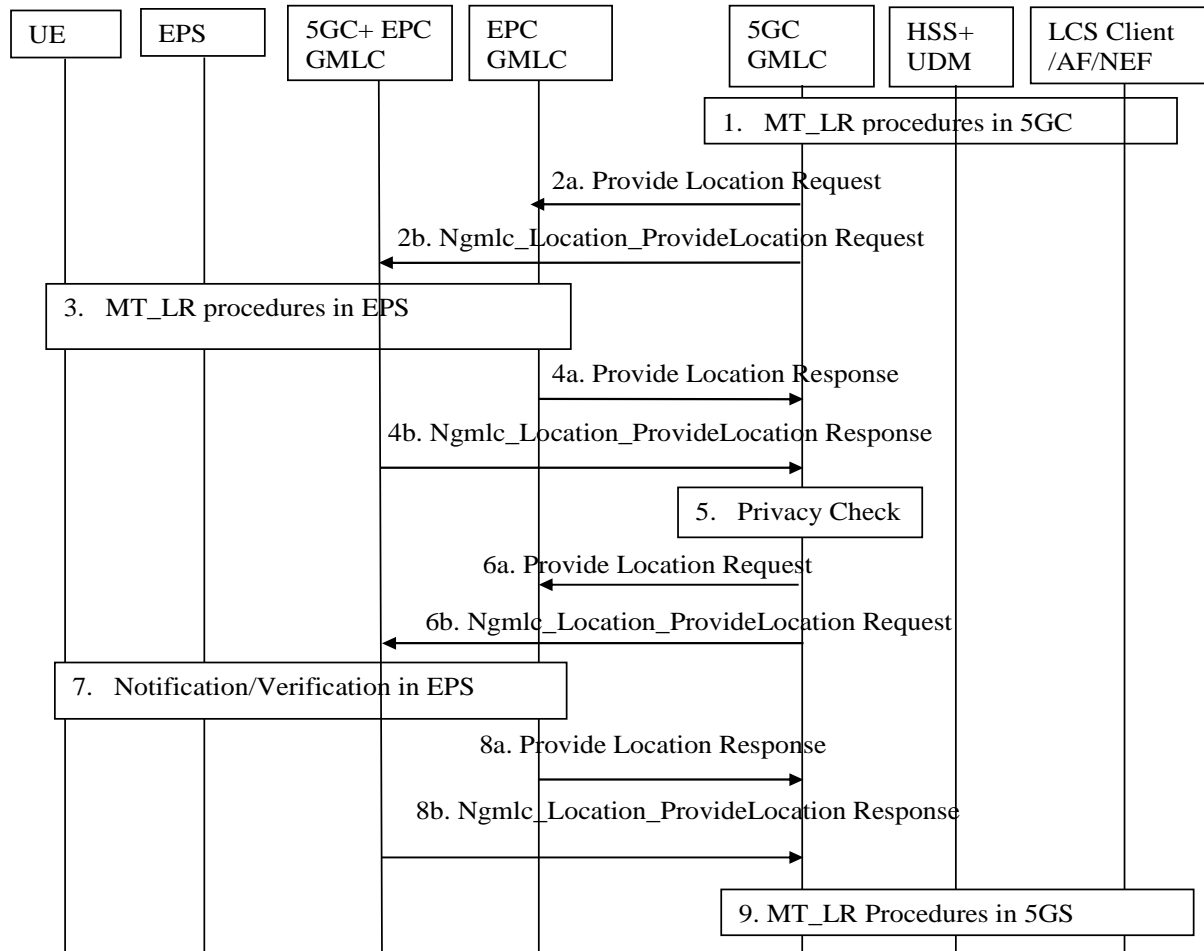


Figure 6.13.1-1: MT-LR procedure with 5GC and EPC interaction

1. Steps 1-3 in clause 6.1.2 are performed.
2. For non-roaming case and if 5GC GMLC and EPC GMLC are combined, steps 2a and 2b are skipped. Otherwise the 5GC GMLC may derive an address of a EPC GMLC or 5GC+EPC GMLC, either received together with the network address of the current serving node) from the UDM/HSS in step 1, by internal configuration or by query to NRF.
- 2a. If an address of a EPC GMLC is derived, the 5GC GMLC then sends the Lr location request to the EPC GMLC. If the result of privacy check indicates that the notification (and verification) based on current location is needed, the 5GC GMLC shall send a location request to the VGMLC indicating "positioning allowed without notification".
- 2b. If an address of an 5GC+EPC GMLC is derived, the 5GC GMLC invokes a Ngmlc_Location_ProvideLocation service operation towards the 5GC+EPC GMLC. If the result of privacy check indicates that the notification

(and verification) based on current location is needed, the 5GC GMLC invokes the service request indicating "positioning allowed without notification"

- 3 Steps 2-9 or 9b in TS 23.271 [4] clause 9.1.15 are performed.
4. For non-roaming case and if 5GC GMLC and EPC GMLC are combined, step 4a and 4b are skipped. Otherwise the following applies:
 - 4a. If step 2a was performed, the EPC GMLC forwards the location estimation of the target UE, its age, its accuracy and optionally the information about the positioning method to the 5GC GMLC.
 - 4b. If step 2b was performed, the 5GC+EPC GMLC forwards the location estimation of the target UE, its age, its accuracy and optionally the information about the positioning method to the 5GC+EPC GMLC in a Ngmlc_Location_ProvideLocation service Response.
5. If the privacy check in step 1 indicates that further privacy checks are needed, the 5GC GMLC shall perform an additional privacy check in order to decide whether the 5GC GMLC can forward the location information to the LCS client or AF or send a notification if the result of the privacy check requires the notification and verification based on current location. One example when this additional privacy check is needed is when the target UE user has defined different privacy settings for different geographical locations. When an additional privacy check is not needed, the (H)GMLC skips steps 6-8.
6. For non-roaming case and if 5GC GMLC and EPC GMLC are combined, step 6a and 6b are skipped. Otherwise the following applies:
 - 6a. If step 2a was performed and if the result of privacy checks in step 5 indicates that the notification (and verification) based on current location is needed, and in the case of roaming, the 5GC GMLC shall send a location request to the EPC GMLC indicating "notification only".
 - 6b. If step 2b was performed and if the result of privacy checks in step 5 indicates that the notification (and verification) based on current location is needed, and in the case of roaming, the 5GC GMLC shall invoke a Ngmlc_Location_ProvideLocation service operation to the 5GC+EPC GMLC indicating "notification only".
7. The EPC post positioning notification and verification procedure in TS 23.271 [4] clause 9.1.18 is performed.
8. For non-roaming case and if 5GC GMLC and EPC GMLC are combined, step 8a and 8b are skipped. Otherwise the following applies:
 - 8a. If step 2a was performed, the EPC GMLC forwards an indication of the result of notification and verification procedure to the 5GC GMLC.
 - 8b. If step 2b was performed, the 5GC+EPC GMLC forwards an indication of the result of notification and verification procedure to the 5GC GMLC.
9. Steps 24 in clause 6.1.2 are performed.

6.13.2 MO-LR Transfer to a Third Party Procedure

Figure 6.13.2-1 illustrates the UE requesting its location to be sent to a Third Party (i.e. an external LCS Client) for the case where the LCS Client is associated with a GMLC in 5GC domain and the UE is served by the EPC domain. Both non-roaming and roaming scenarios are described. For non-roaming scenario both the case of separate 5GC GMLC and EPC GMLC connected with Lr reference point and the case with co-located 5GC GMLC and EPC GMLC are described. For roaming scenario, when the combined 5GC GMLC and EPC GMLC are deployed in the HPLMN, it uses NL3 to interconnect with the EPCGMLC in the VPLMN.

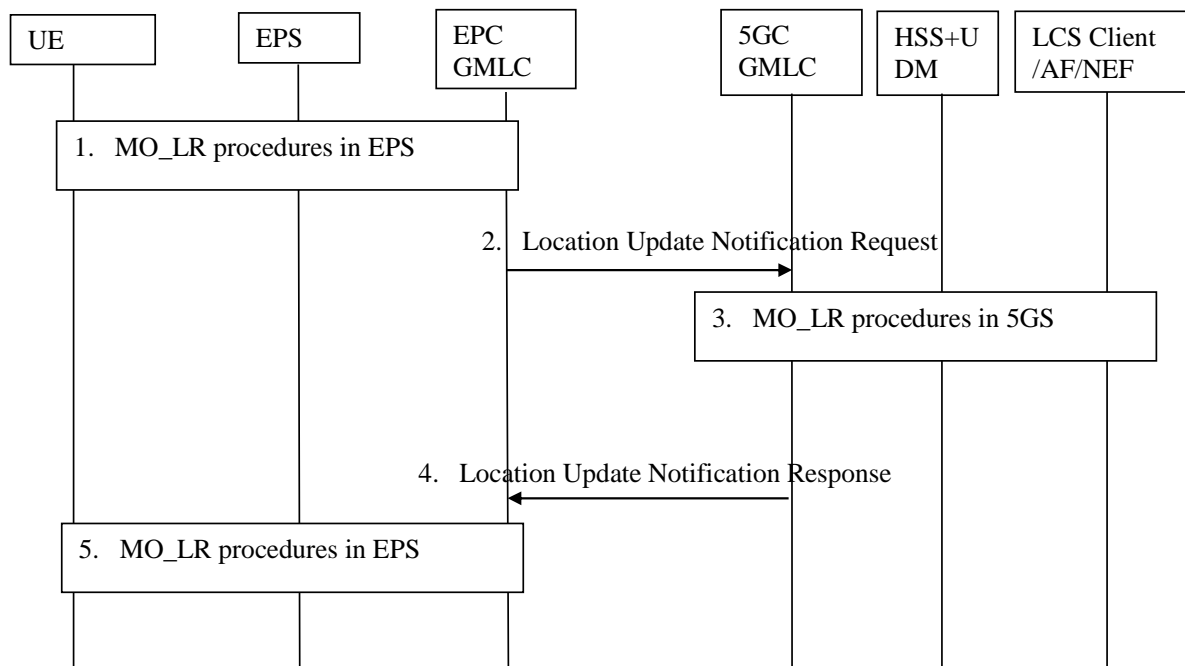


Figure 6.13.2-1: MO-LR procedure with 5GC and EPC interaction

1 Steps 1-6 in TS 23.271 [4] clause 9.2.6 are performed.

2. For non-roaming case and if 5GC GMLC and EPC GMLC is combined, this step is skipped. Otherwise the EPC GMLC sends Location Update Notification Request towards to the 5GC GMLC including the information received in step 1.

3 Steps 9-10 in clause 6.2 are performed.

4. For non-roaming case and if 5GC GMLC and EPC GMLC are combined, this step is skipped. Otherwise if the identified LCS Client is not accessible, the EPC GMLC sends a Location Update Notification response to AMF with an appropriate error cause. Otherwise, the response shall include an acknowledgement. The message shall specify whether the location estimate of the UE has been handled successfully by the identified LCS Client, and if not, the corresponding error cause obtained in step.

5 Steps 13-14 in TS 23.271 [4] clause 9.2.6 are performed.

6.14 Procedures for Broadcast of Assistance Data

6.14.1 Broadcast of Assistance Data by an LMF

The following procedure is used by the LMF to support broadcasting of network assistance data to target UEs. This procedure is not associated with a UE location session. It is used in an AMF to send network assistance data to an NG-RAN node for broadcasting by the NG-RAN node to target UEs. NG-RAN positioning procedures related to LMF and NG-RAN node communication are specified in TS 38.455 [15].

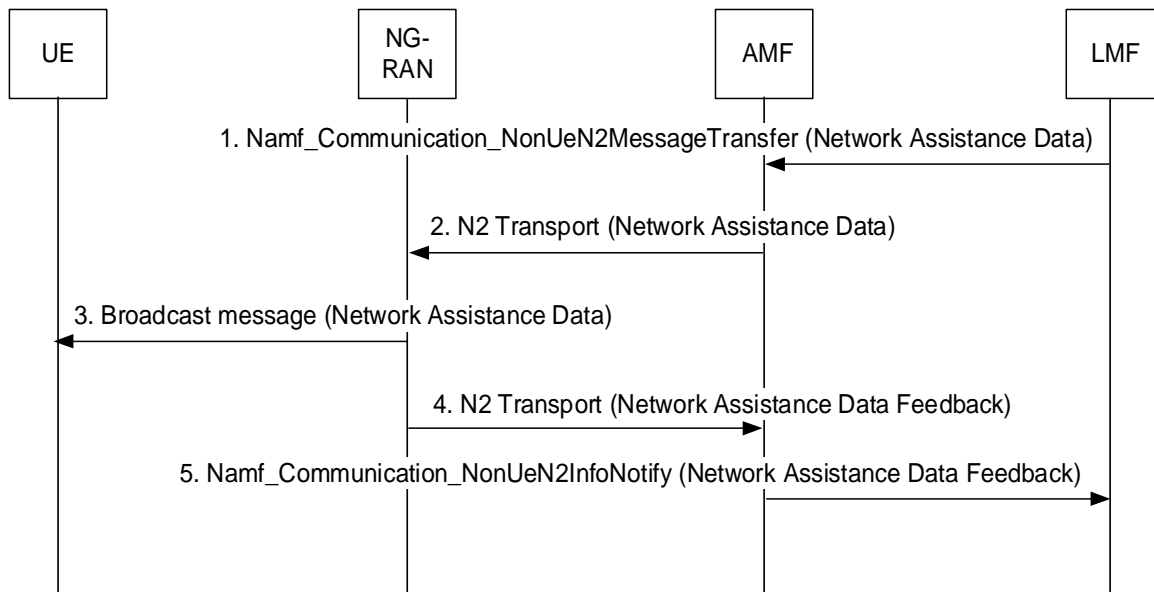


Figure 6.14.1-1: Broadcasting Network Assistance Data

1. The LMF invokes the `Namf_Communication_NonUeN2MessageTransfer` service operation towards the AMF to request the transfer of a Network Assistance Data message to an NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the Network Assistance Data message and the target NG-RAN node identity. The Network Assistance Data message includes assistance data which may be optionally ciphered.
2. The AMF forwards the Network Assistance Data message to the target NG-RAN node indicated in step 1 in an N2 Transport message. The AMF includes a Routing identifier, in the N2 Transport message, identifying the LMF.
3. The NG-RAN node broadcasts the assistance data contained in the Network Assistance Data message.
4. The target NG-RAN node may return feedback on assistance information broadcasting to the AMF in a Network Assistance Feedback message. The target NG-RAN node shall also include the Routing identifier in the N2 Transport message received in step 2.
5. The AMF invokes the `Namf_Communication_NonUeN2InfoNotify` service operation towards the LMF indicated by the routing identifier received in step 4. The service operation includes the Network Assistance Data Feedback message received in step 4.

6.14.2 Delivery of Ciphering Keys to UEs for Broadcast Assistance Data

The following procedure is used by the LMF and the AMF to distribute ciphering keys to UEs to enable UEs to decipher broadcast assistance data that was ciphered by the LMF. This procedure is not associated with a UE location session. The procedure makes use of the Registration procedure defined in TS 23.502 [19].

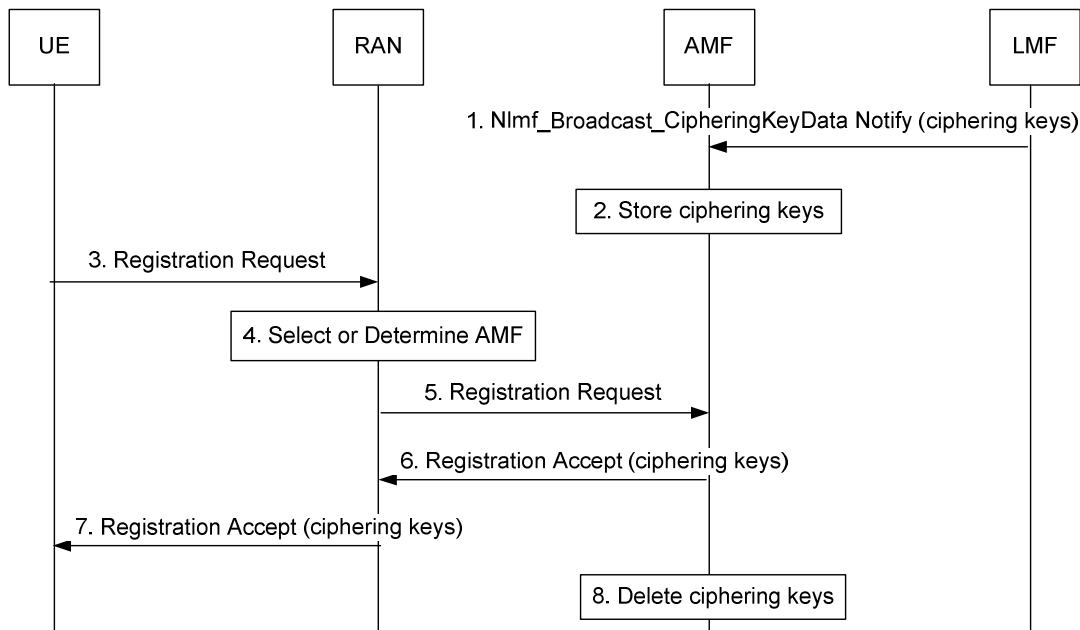


Figure 6.14.2-1: Delivery of Ciphering Keys to UEs for Broadcast Assistance Data

1. The LMF invokes the Nlmf_Broadcast_CipheringKeyData Notify service operation towards the AMF carrying one or more ciphering keys used to cipher network assistance data that is broadcast to UEs according to the procedure in clause 6.14.1. For each ciphering key, the LMF includes a ciphering key value, a ciphering key identifier, a validity period, a set of applicable tracking areas and a set of applicable types of broadcast assistance data.

NOTE 1: The LMF may send a new ciphering key to the AMF at a time T1 if this will start to be used to cipher network assistance data at a later time T2 (e.g. will replace a previous ciphering key which expires at time T2). The value of (T2 - T1) should exceed the longest periodic registration timer of any UE subscribed to receive ciphering keys to ensure that periodic registration can be used to request new ciphering keys as described in note 2.

2. The AMF stores the ciphering keys including the validity periods, applicable tracking areas and the types of applicable broadcast assistance data.
3. A UE sends a Registration Request to a RAN node. The Registration Request may be sent as part of normal mobility management, A Registration Request may also be sent specifically to request and obtain ciphering keys. The UE includes in the Registration Request an indication that ciphering keys are requested. Other details of the Registration Request are as defined in TS 23.502 [19].

NOTE 2: A UE should request new ciphering keys using a Registration Request caused by periodic registration if the remaining validity period for one or more ciphering keys received earlier by the UE is less than the periodic registration timer value. This can help avoid all UEs initiating a Registration procedure at the same time to obtain new ciphering keys when a validity period for a ciphering key is about to expire. A UE should also request new ciphering keys for a Registration Request caused by entering a new tracking area if previous ciphering keys are not applicable to the new tracking area.

4. The RAN node selects the AMF if the UE is in CM IDLE state or determines the AMF for CM CONNECTED state.
5. The RAN node forwards the Registration Request to the AMF.
6. The AMF returns a Registration Accept to the RAN node as defined in TS 23.502 [19]. If the UE is subscribed to receive ciphered broadcast data, the AMF includes in the Registration Accept one or more ciphering keys applicable to the current tracking area for the UE. The AMF also includes for each ciphering key the ciphering key value, the ciphering key identifier, the validity period, the set of applicable tracking areas and the set of applicable types of broadcast assistance data.

NOTE 3: The AMF does not need to keep a record of ciphering keys delivered to a UE and may instead send all ciphering keys stored at step 2 that are applicable to the current tracking area, for which the UE has a subscription and whose validity period has not yet expired.

7. The RAN node forwards the Registration Accept to the UE. The UE may start to use each ciphering key to decipher network assistance data that is broadcast according to the procedure in clause 6.14.1 once the validity period for the ciphering key has started and if the UE is currently in an applicable tracking area. The UE shall cease using a ciphering key when entering a tracking area not applicable to the ciphering key. The UE shall cease using and shall delete a ciphering key when the validity period for the ciphering key has expired.

NOTE 4: A UE that receives no ciphering keys in response to a request for ciphering keys may assume that the UE does not have a subscription to receive ciphering keys in the serving PLMN.

8. The AMF deletes all information for a ciphering key when the validity period has expired.

7 Information storage

7.1 UDM

For each UE subscriber the UDM stores LCS related data as part of the Subscriber Data Management (SDM) service as defined in clause 5.2.3.3.1 of TS 23.502 [19].

The privacy profile data is defined in table 7.1-1 containing data for the privacy classes for which location of the target UE is permitted. For the meaning of each LCS privacy profile data type and included data, refer to clause 5.4.2.

Table 7.1-1: LCS privacy profile data stored in the UDM for a UE Subscriber

Privacy Profile Data Type	Presence	UDM data
Location Privacy Indication	M	Indication of one of the following mutually exclusive global settings: <ul style="list-style-type: none"> - Location is disallowed - Location is allowed (default)
	O	Time period when the Location Privacy Indication is valid
Call/session Unrelated Class	M	For any LCS client or AF not in the external LCS client list or otherwise identified for the Call/session Unrelated Class, the following data may be present:
	O	<ul style="list-style-type: none"> - One of the following mutually exclusive options: <ul style="list-style-type: none"> - Location not allowed (default case) - Location allowed with notification - Location with notification and privacy verification; location allowed if no response - Location with notification and privacy verification; location restricted if no response
	O	<ul style="list-style-type: none"> - Time period when positioning is allowed
	O	<ul style="list-style-type: none"> - Geographical area where positioning is allowed
	O	<ul style="list-style-type: none"> - Indication that codeword shall be checked in UE or one or more codeword values to be checked in GMLC
	O	External LCS client list: a list of zero or more LCS clients, AFs and LCS Client groups with the following data for each entry:
	O	<ul style="list-style-type: none"> - One of the following mutually exclusive options: <ul style="list-style-type: none"> - Location allowed without notification (default case) - Location allowed with notification - Location with notification and privacy verification; location allowed if no response - Location with notification and privacy verification; location restricted if no response
	O	<ul style="list-style-type: none"> - Time period when positioning is allowed
	O	<ul style="list-style-type: none"> - Geographical area where positioning is allowed
	O	Service types list: a list of one or more service types for which the LCS client is allowed to locate the particular UE. The possible service types are defined in TS 22.071 [2]. The following data may be present for each service type in the list:
	O	<ul style="list-style-type: none"> - One of the following mutually exclusive options: <ul style="list-style-type: none"> - Location allowed without notification (default case) - Location allowed with notification - Location with notification and privacy verification; location allowed if no response - Location with notification and privacy verification; location restricted if no response
O	<ul style="list-style-type: none"> - Time period when positioning is allowed 	
O	<ul style="list-style-type: none"> - Geographical area where positioning is allowed 	
O	<ul style="list-style-type: none"> - Indication that codeword shall be checked in UE or one or more codeword values to be checked in GMLC 	
PLMN Operator Class	O	LCS client list: a list of one or more generic classes of LCS client that are allowed to locate the particular UE. The following classes are distinguished: <ul style="list-style-type: none"> - LCS client broadcasting location related information - O&M LCS client in the HPLMN - O&M LCS client in the VPLMN - LCS client recording anonymous location information - LCS Client supporting a bearer service, teleservice or supplementary service to the target UE

The Mobile Originating data is defined in table 7.1-1 containing the LCS MO-LR services that a UE can receive.

Table 7.1-2: LCS Mobile Originated data for a UE Subscriber

MO-LR Data	Presence	UDM data
Mobile Originated data	M	List of MO-LR services allowed for a UE subscriber: <ul style="list-style-type: none"> - Basic Self Location (UE can receive its own location) - Autonomous Self Location (UE can receive location assistance data) - Transfer to Third Party

Table 7.1-3: LCS broadcasting data for a UE subscriber

Broadcasting Data	Presence	Description
List of Assistance Data Types	O	A list of one or more types of location assistance data for which ciphering keys should be provided to the UE if requested by the UE when the assistance data is broadcast using ciphering.

7.2 GMLC

7.2.1 Information for an LCS Client

The GMLC holds information for external LCS clients which are permitted to request location information for UE subscribers. Table 7.2.1-1 shows the information which may be stored in the GMLC for an external LCS Client.

Table 7.2.1-1: GMLC Information for an External LCS Client

LCS Client Information	Status	Description
LCS Client Type	M	Identifies the type of LCS client from among the following: <ul style="list-style-type: none"> - Emergency Services - Value Added Services - PLMN Operator Services - Lawful Intercept Services
External identifier	O	A list of one or more identifiers used to identify an external LCS client. The identifier may be used for a 5GC-MT-LR and/or 5GC-MO-LR. The format of the identifier is an international E.164 address, ITU-T Recommendation E.164 [23].
Authentication data	MO	Data employed to authenticate an external LCS client if the authentication is not done by a security gateway – details are outside the scope of the present document
Internal identifier	O	Identifies the sub-type of a PLMN operator services LCS Client from among the following: <ul style="list-style-type: none"> - LCS client broadcasting location related information - O&M LCS client in the HPLMN - O&M LCS client in the VPLMN - LCS client recording anonymous location information - LCS Client supporting a bearer service, teleservice or supplementary service to the target UE
Client name	O	An address string which is associated with the LCS client's external identity (i.e., E.164 address).
Client name type	O	Indication of the type of the LCS client name. The type of the LCS client name can be one of the following: <ul style="list-style-type: none"> - Logical name - MSISDN - E-mail address (RFC 2396 [25]) - URL (RFC 2396 [25]) - SIP URL (RFC 3261 [26]) - IMS public identity (1 23.228 [27]) - GPSI
Privacy Override Indication	O	Indication of whether the LCS client possesses the POI capability (only applicable to lawful intercept and emergency services clients)
Authorized UE List	O	A list of SUPIs and/or groups of SUPI for which the LCS client may issue a request for a 5GC-MT-LR for immediate or deferred location.
Priority	O	The priority of the LCS client
QoS parameters	M	The default QoS requirements for the LCS client, comprising: <ul style="list-style-type: none"> - Accuracy - Response time - LCS QoS Class
Service Coverage	O	A list of E.164 country codes for geographic areas, ITU-T Recommendation E.164 [23] where the LCS client is permitted to request and receive UE location information.
Allowed LCS Request Types	M	Indicates which of the following are allowed: <ul style="list-style-type: none"> - Request of current immediate location - Request of current or last known immediate location - Request of deferred location for the UE available event - Request of deferred location for UE periodic events - Request of deferred location for the Area Event - Request of deferred location for the Motion Event
Local Co-ordinate System	O	Definition of the co-ordinate system(s) in which a location estimate shall be provided – details are outside the scope of the present document
Access Barring List(s)	O	List(s) of SUPIs or groups of SUPI for which a location request is barred
Service types	O	List of service type allowed for the LCS client.
Maximum Target UE Number	O	The maximum number of the Target UEs in one LCS request. For a specific LCS Client, this parameter may have different values for different service types.

8 Network Function Services

8.1 AMF Services

AMF services related to location service are defined in TS 23.502 [19] clause 5.2.2.

8.2 UDM Services

UDM services related to location service are defined in TS 23.502 [19] clause 5.2.3.

8.3 LMF Services

8.3.1 General

The following table shows the LMF Services and LMF Service Operations.

Table 8.3.1-1: List of LMF Services

Service Name	Service Operations	Operation Semantics	Example Consumer(s)
Nlmf_Location	DetermineLocation	Request/Response	AMF
	EventNotify	Notify	GMLC
	CancelLocation	Request/Response	AMF
	LocationContextTransfer	Request/Response	LMF
Nlmf_Broadcast	CipheringKeyData	Notify	AMF

8.3.2 Nlmf_Location service

8.3.2.1 General

Service description: This service enables an NF to request location determination for a target UE. The following are the key functionalities of this NF service.

- Allow the consumer NF to request the current geodetic and optionally civic location of a target UE.
- Allow the consumer NF to subscribe/unsubscribe the geodetic and optionally civic location of a target UE for some certain events.
- Allow the consumer NF to get notified about the geodetic and optionally civic location of a target UE when some certain events are detected.
- Allows the consumer NF to cancel location event reporting for a target UE.
- Allows the consumer NF to transfer location context information for location event reporting for a target UE.

The events to trigger location estimation notification are defined in clause 4.1a.5.1

8.3.2.2 Nlmf_Location_DetermineLocation service operation

Service operation name: Nlmf_Location_DetermineLocation

Description: Provides UE location information to the consumer NF.

NOTE: For deferred location request, this service operation is used to implicitly subscribe to the notification of the UE location information.

Input, Required: Client Type, LCS Correlation Identifier.

Input, Optional: Serving cell identifier of the Primary Cell in the Master RAN node and the Primary Cell in the Secondary RAN node when available based on Dual Connectivity scenarios if the UE is using 3GPP access, Location QoS, Supported GAD shapes, service type, AMF identity if a UE associated Namf_Communication service is to be invoked by LMF, Type of request for a 5GC-MO-LR, Embedded LPP message for a 5GC-MO-LR, Deferred location type, Deferred location parameters, indication if UE supports LPP or not, Notification Target Address, Notification Correlation ID.

Output, Required: Success/Failure indication

Output, Optional: Geodetic Location, Civic Location, Position Methods Used (in the case of success indication provided), Serving LMF identification, Failure Cause (in the case of failure indication provided).

See clause 6.1, clause 6.2. and clause 6.3.1 for examples of usage of this service operation.

8.3.2.3 Nlmf_Location_EventNotify service operation

Service operation name: Nlmf_Location_EventNotify.

Service operation description: Allow the consumer NF to get notified about the geodetic and optionally civic location of a target UE when some certain events are detected, either the events implicitly subscribed by the AMF using Nlmf_Location_DetermineLocation service operation or the cancellation of reporting of periodic or triggered location events.

Input, Required: Notification Correlation ID, UE (SUPI and if available GPSI), Type of event.

Input, Optional: Geodetic Location, Civic Location, Position Methods Used (in the case of success indication provided), Notification Target address, Serving LMF identification, Failure Cause (in the case of failure indication provided).

Output, Required: None.

Output, Optional: Success/Failure indication.

See clause 6.3.1 and clause 6.3.2 for examples of usage of this service operation.

8.3.2.4 Nlmf_Location_CancelLocation service operation

Service operation name: Nlmf_Location_CancelLocation

Description: The consumer NF cancels a deferred 5GC-MT-LR procedure for periodic or triggered location request.

Input, Required: Notification Target Address, Notification Correlation ID.

Input, Optional: None.

Output, Required: Success/Failure indication

Output, Optional: None.

See clause 6.3.3 for an example of usage of this service operation.

8.3.2.5 Nlmf_Location_LocationContextTransfer service operation

Service operation name: Nlmf_Location_LocationContextTransfer

Description: Transfers location context information for location event reporting for a target UE from the consumer NF.

Input, Required: AMF identity, Location QoS, Supported GAD shapes, Deferred location type, Deferred location parameters, Notification Target Address, Notification Correlation ID, Embedded event report message.

Input, Optional: Event reporting status, UE location information.

Output, Required: Success/Failure indication

Output, Optional: None.

See clause 6.4 for an example of usage of this service operation.

8.3.3 Nlmf_Broadcast service

8.3.3.1 General

Service description: This service enables an NF to receive information related to broadcast of location assistance by an LMF. The following are the key functionalities of this NF service.

- Allow the consumer NF to be notified about ciphering keys used to cipher broadcast assistance data.

The events to trigger ciphering key notification are defined in clause 6.14.2.

8.3.3.2 Nlmf_Broadcast_CipheringKeyData service operation

Service operation name: Nlmf_Broadcast_CipheringKeyData

Description: Provides ciphering key data to the consumer NF.

Input, Required: For each ciphering key: ciphering key value, ciphering key identifier, validity period, set of applicable types of broadcast assistance data.

Input, Optional: For each ciphering key: set of applicable tracking areas.

Output, Required: For each ciphering key: ciphering key identifier, success/failure indication.

Output, Optional: none.

See clause 6.14.2 for an example of usage of this service operation.

8.4 GMLC Services

8.4.1 General

The following table shows the GMLC Services and GMLC Service Operations.

Table 8.4.1-1: List of GMLC Services

Service Name	Service Operations	Operation Semantics	Example Consumer(s)
Ngmlc_Location	ProvideLocation	Request / Response	GMLC, NEF
	LocationUpdate	Request / Response	AMF, GMLC
	LocationUpdateNotify	Notify	NEF
	CancellLocation	Request / Response	GMLC, NEF
	EventNotify	Notify	GMLC, NEF

8.4.2 Ngmlc_Location service

8.4.2.1 General

Service description: This service enables an NF to request location determination for a target UE. The following are the key functionalities of this NF service.

- Allow the consumer NF to request the current geodetic and optionally civic location of a target UE.
- Allow the consumer NF to subscribe/unsubscribe the geodetic and optionally civic location of a target UE for some certain events.
- Allow the consumer NF to cancel an on-going periodic or triggered location request of a target UE.
- Allow the consumer NF to get notified about the geodetic and optionally civic location of a target UE when some certain events are detected.

8.4.2.2 Ngmlc_Location_ProvideLocation service operation

Service operation name: Ngmlc_Location_ProvideLocation

Description: Provides UE location information to the consumer NF.

NOTE 1: For deferred location request, this service operation is used to implicitly subscribe to the notification of the UE location information.

NOTE 2: For bulk LCS service request from NEF to GMLC, this service operation is used to implicitly subscribe to the notification of UE location information

Input, Required: UE identifier (GPSI, SUPI, Internal Group Identifier or External Group Identifier), Client Type.

Input, Optional: Required QoS, Supported GAD shapes, UE privacy requirements, LCS Client Identification, Service type, Notification Target Address, Notification Correlation ID, Event Type (defined in clause 4.1a.5.1), and:

- For periodic event type, optional input further includes the time interval between successive location reports, the total number of reports, location QoS.
- For area event type, optional input further includes target geographical area, whether the event to be reported is the UE being inside, entering into or leaving the target area, the duration of event reporting, the minimum and maximum time intervals between successive event reports, the maximum event sampling interval, whether location estimates and associated location QoS shall be included in event reports, and whether only one location report is required or more than one.
- For motion event type, optional input further includes the threshold linear distance, the duration of event reporting, the minimum and maximum time intervals between successive event reports, the maximum event sampling interval, whether location estimates and associated location QoS shall be included in event reports, and whether only one location report is required or more than one.

Output, Required: Success/Failure indication

Output, Optional: Geodetic location, civic location, age of location, position methods used (in the case of success indication provided), failure cause (in the case of failure indication provided).

See clauses 6.3.1 and 6.8 for examples of usage of this service operation.

8.4.2.3 Ngmlc_Location_LocationUpdate service operation

Service operation name: Ngmlc_Location_LocationUpdate

Description: Consumer NF provides UE location information to the GMLC.

Input, Required: UE identifier (GPSI or SUPI), event causing the location estimate (5GC-MO-LR), location estimate, age of location estimate, accuracy indication, LCS QoS class.

Input, Optional: pseudonym indicator, identity of the LCS client, identity of the AF, GMLC address, service identity specified by UE.

Output, Required: Success/Failure indication

Output, Optional: Failure Cause (in the case of failure indication provided).

See clause 6.2 for example of usage of this service operation.

8.4.2.4 Ngmlc_Location_EventNotify service operation

Service operation name: Ngmlc_Location_EventNotify

Description: Allow the consumer NF to get notified about the geodetic and optionally civic location of one or more target UEs when some certain events, either the events implicitly subscribed by the AMF using Ngmlc_Location_ProvideLocation service operation, or the cancellation of reporting of periodic or triggered location events, are detected or at bulk reporting of location.

Input, Required: Notification Correlation ID, UE (SUPI and if available GPSI), Type of location related event (e.g. deferred location for the UE available event, activation of location for periodic or triggered location, mobility of a target UE to a new AMF or MME for a deferred location).

Input, Optional: Geodetic Location, Civic Location, Position Methods Used (in the case of success indication provided), Failure Cause (in the case of failure indication provided), address of a new AMF or MME.

Output, Required: None.

Output, Optional: None.

See clauses 6.3 and 6.8 for examples of usage of this service operation.

8.4.2.5 Ngmlc_Location_CancelLocation service operation

Service operation name: Ngmlc_Location_CancelLocation

Description: The consumer NF uses this service operation to cancel a deferred 5GC-MT-LR procedure for periodic or triggered location.

Input, Required: UE Identification (SUPI), Notification Target address, Notification Correlation ID.

Input, Optional: None.

Output, Required: None.

Output, Optional: None.

See clause 6.3.3 for example of usage of this service operation.

8.4.2.6 Ngmlc_Location_LocationUpdateNotify service operation

Service operation name: Ngmlc_Location_LocationUpdateNotify

Description: Provides UE location information to the consumer NF.

Input, Required: UE identifier (GPSI or SUPI), identity of the AF, event causing the location estimate (5GC-MO-LR), location estimate, age of location estimate, accuracy indication, LCS QoS class.

Input, Optional: None.

Output, Required: Success/Failure indication.

Output, Optional: Failure Cause (in the case of failure indication provided).

See clause 6.2 for example of usage of this service operation.

8.5 NEF Services

For 5GC-MT-LR procedures, location reporting is one of the monitoring events, as defined in clause 4.15.3.1 of TS 23.502 [19], supported by Nnef_EventExposure service.

Nnef_EventExposure service operations are defined in TS 23.502 [19] clause 5.2.6.2.

The attributes that may be included in the location service request and response are listed in clause 5.5.

For 5GC-MO-LR procedure, if UE requests to report its location to AF, the location reporting is supported by Nnef_Location_LocationUpdateNotify service operation defined in TS 23.502 [19] clause 5.2.6.21.

8.6 UDR Services

UDR services related to location service are defined in TS 23.502 [19] clause 5.2.3.

Annex A (informative): Differences with TS 23.271 [4]

A.0 General

Differences with TS 23.271 [4] are described here where these may impact service to a target UE, LCS client, or client AF or NF. The differences are restricted to those applicable to a UE with EPS access in the case of TS 23.271 [4] and do not include all differences applicable to GERAN or UTRAN access.

A.1 Differences in Parameters for a Location Request

Table A.1-1 shows a list of parameters applicable to a location request sent by an external LCS client to a GMLC which are defined in TS 23.271 [4], differences if any with this TS, and comments on these including any significant consequences.

Table A.1-1: Differences in Parameters for a Location Request with TS 23.271 [4]

Location Request Parameter	Difference	Comments
Target UE Identity	GPSI, SUPI or pseudonym in this TS MSISDN, IMSI or pseudonym in TS 23.271 [4]	
LCS QoS	None	
Supported GAD shapes	None	
LCS Client type	None	
Called Party Number	Not supported in this TS	If provided, this parameter should be ignored by a GMLC
APN NI	Not supported in this TS	If provided, this parameter should be ignored by a GMLC
Service Identity	None	
Codeword	None	
Service coverage information	None	
Requestor Identity	Not supported in this TS	If provided, this parameter should be ignored by a GMLC
Type of Requestor Identity	Not supported in this TS	If provided, this parameter should be ignored by a GMLC
Type of a deferred location request	None	
Periodic Location parameters	None	
Area Event parameters	None	
Motion Event parameters	None	

A.2 Differences in Information Storage in the UDR/UDM versus HSS/GMLC for EPS

Table A.2-1 shows a list of LCS information storage items for a UE in the UDR and UDM defined in this TS and for the HSS and/or GMLC defined in TS 23.271 [4], differences if any between this TS and TS 23.271 [4], and comments on these including any significant consequences.

Table A.2-1: Differences in Information Storage for a UE in the UDR/UDM versus HSS/GMLC for EPS

Information Storage Item(s)	Difference	Comments
UE Privacy Universal Class	Not supported in this TS	This privacy class should not be supported for 5GC capable UEs on the EPS side to avoid differences in LCS privacy support between EPS access and 5GS access for the same UE. (Note 1)
UE Location Privacy Indication	Not supported in TS 23.271 [4]	This indication can create differences between LCS client access to a UE which has 5GS access versus EPS access. (Note 1)
UE Privacy Call/Session related Class	Not supported in this TS	This privacy class should not be supported for 5GC capable UEs on the EPS side to avoid differences in LCS privacy support between EPS access and 5GS access for the same UE. (Note 1)
UE Privacy Call/Session unrelated Class	Supported as defined in TS 23.271 [4] with the following differences: <ul style="list-style-type: none"> - Information related to an RGMLC is not included - An optional time period is not supported in TS 23.271 [4] - An optional geographic area is not supported in TS 23.271 [4] 	This privacy class can create differences between LCS client access to a UE which has 5GS access versus EPS access. (Note 1)
UE Privacy PLMN Operator Class	None	
UE LCS Mobile Originating Data	None	
NOTE 1: A PLMN operator can avoid any difference in UE privacy support for EPS access versus 5GS access by only storing information for UE privacy (in the UE LCS privacy profile) in a UDR (and UDM) and not in an HSS or GMLC.		

A.3 Differences in Information Storage in the GMLC

Table A.3-1 shows a list of information storage items in the GMLC for an LCS Client defined in this TS and in TS 23.271 [4], differences if any between this TS and TS 23.271 [4], and comments on these including any significant consequences.

Table A.3-1: Differences in Information Storage for an LCS Client in the GMLC

Information Storage Item(s)	Difference	Comments
LCS Client Type	None	
External identity	None	
Authentication data	None	
Call/session related identity	Not supported in this TS	This information item can create differences between LCS client access to a UE which has 5GS access versus EPS access. (Note 1)
Internal identity	None	
Client name	None	
Client name type	No difference except that this TS adds a Client Name type in the form of a GPSI.	A GPSI can be an MSISDN or External Identifier in the form of "username@realm" as defined in TS 23.003 [28]. TS 23.271 [4] allows an MSISDN but the External Identifier is not included.
Override capability	None	
Authorized UE List	None	
Priority	None	
QoS parameters	None	
Service Coverage	None	
Allowed LCS + Request Types	<p>TS 23.271 [4] includes the following items which are not in this TS:</p> <ul style="list-style-type: none"> - Non-call related CS-MT-LR/PS-MT-LR/EPC-MT-LR - Call/session related CS-MT-LR/PS-MT-LR/EPC-MT-LR - Specification or negotiation of priority - Specification or negotiation of QoS parameters - Specification or negotiation of Service Coverage parameter <p>This TS includes the following items which are not in TS 23.271 [4]:</p> <ul style="list-style-type: none"> - Request of deferred location for the UE available event - Request of deferred location for UE periodic events - Request of deferred location for the Area Event - Request of deferred location for the Motion Event 	This TS should take precedence (Note 1)
Local Co-ordinate System	None	
Access Barring List(s)	TS 23.271 [4] includes a list of MSISDNs. This TS includes a list of SUPIs	This TS can take precedence (Note 1)
Service Identities	None	
Maximum Target UE Number	None	
NOTE 1: A PLMN operator can avoid any difference in LCS Client support for a target UE with EPS access versus 5GS access by only storing information for an LCS Client in a GMLC as defined in this TS.		

A.4 Differences with TS 23.271 [4] on Privacy

A.4.1 Differences in UE LCS Privacy

Table A.4.1-1 shows a list of UE LCS privacy features defined in this specification and in TS 23.271 [4], differences if any between these, and comments on these including any significant consequences.

Table A.4.1-1: Differences in UE LCS Privacy with TS 23.271 [4]

UE LCS Privacy Feature	Difference	Comments
Privacy Override Indicator (POI)	None	
UE Privacy Universal Class	Not supported in this TS	This class allows a UE to subscribe to location by any LCS client. For such a UE, a 5GC GMLC will not support such location.
Location Privacy Indication	Not supported in TS 23.271 [4]	As defined in clause 5.4.2.3.
UE Privacy Call/Session related Class	Not supported in this TS	This class permits location by LCS clients to which the UE has established a PS session. A 5GC GMLC will not allow such location. However, the location can be allowed as part of the Call/Session unrelated class.
UE Privacy Call/Session unrelated Class	Supported as defined in TS 23.271 [4] with the following differences: An optional valid time period is added An optional valid geographic area is added	The optional valid time period and valid geographic area allow more precise control of location reporting. For example, tracking of employees by an employer can be restricted to a work location and/or normal work hours.
UE Privacy PLMN Operator Class	Supported as defined in TS 23.271 [4]	

Annex B (informative): LCS privacy selection rule in serving NF

B.1 LCS privacy selection flow rule

A 5GS-MT-LR may be applied to more than one LCS privacy data in the LCS privacy profile, e.g. one or more privacy classes as defined in clause 5.4.2.2 and LPI as defined in clause 5.4.2.3. The 5GS-MT-LR may also require POI as defined in clause 5.4.4. The Privacy selection flow is shown in Figure B.1-1.

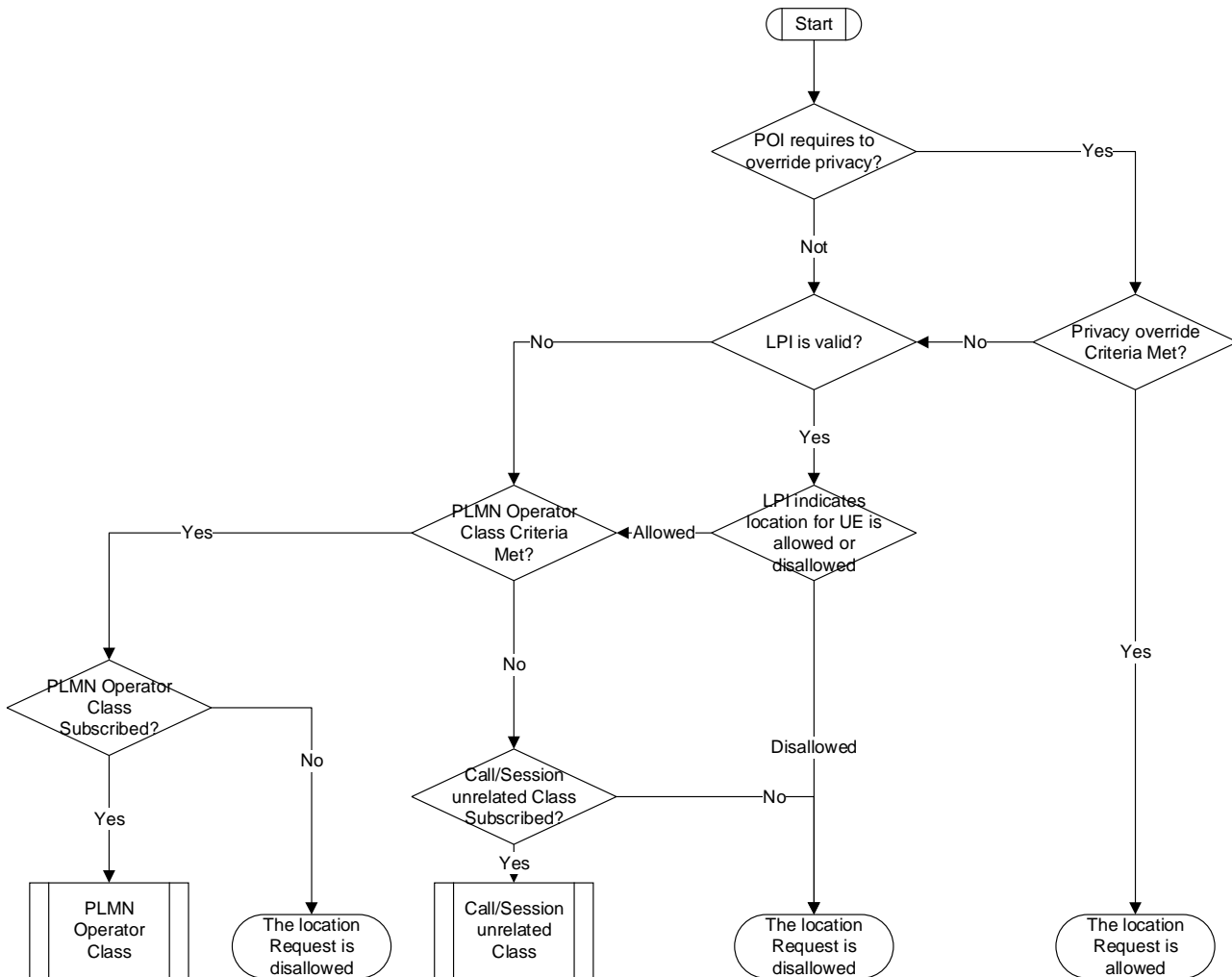


Figure B.1-1: Privacy selection flow diagram

Annex C (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2019-05	SP#84	SP-190455	-	-	-	MCC Editorial update for presentation to TSG SA#84 for approval	1.0.0
2019-06	SP#84	-	-	-	-	MCC editorial update for publication after approval at TSG SA#84	16.0.0
2019-09	SP#85	SP-190606	0001	1	F	Correction on UE Assisted and UE Based Positioning Procedure	16.1.0
2019-09	SP#85	SP-190606	0002	1	F	Correction on LCS privacy selection flow rule	16.1.0
2019-09	SP#85	SP-190606	0003	-	F	Corrections to EPC Interconnection	16.1.0
2019-09	SP#85	SP-190606	0005	1	F	Corrections to LCS Privacy feature	16.1.0
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2020-03	SP#87E	SP-200064	0107	1	F	Correction to roaming architecture for NEF	16.3.0
2020-03	SP#87E	SP-200064	0108	-	F	Correction to LMF function	16.3.0
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2020-07	SP#88E	SP-200423	0120	1	F	Add NEF function in location service exposure procedure	16.4.0
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History

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