**3GPP TSG-RAN WG2 Meeting #109bis-eR2-2003990**

**Online, April 20 – 30, 2020**

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| *CR-Form-v12.0* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.305** | **CR** | **DRAFT** | **rev** | **-** | **Current version:** | **16.0.0** |  |
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| *For* [***HELP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **x** | Radio Access Network | **x** | Core Network |  |

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| ***Title:*** | Various Corrections to NR Positioning | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Qualcomm Incorporated | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_pos-Core | | | | |  | ***Date:*** | | | 2020/04/24 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | F |  | | | | | ***Release:*** | | | Rel-16 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12) Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | This contribution proposes some corrections to NR positioning. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | 1. MO-LR has been added to Rel-16, but 38.305 mentions that MO-LR is not supported in this Release.  Description for MO-LR is added.  References to TS 23.273 are added at multiple places. 2. RRC protocol in Rel-16 is also used for postioning SRS configuration. A brief description is added to 6.2.2. 3. Rel-16 NR positioning support can also make use of MAC commands. A new section 6.2.4 is proposed. 4. Section 5.1 mentions that NG-RAN architecture to support positioning is described in 38.401. However, this seems not being the case. The sentence is proposed to be deleted. 5. The interface name between LMF and AMF is changed to “NL1” in TS 23.273, which is corrected in Figures 6.4.1-1 and 6.5.1-1. 6. Table 8.9.2.2-1 mentions that Cell Portion ID is transfered from UE to LMF for E-CID positioning. However, a Cell Portion ID can not be determined at the UE and therefore, is proposed to be deleted from the Table. 7. Table 8.10.2.4-2, 8.13.2.3-2, and 8.14.2.3-2 mentions that “PCI, GCI, and TRP ID of the TRP for the UE to transmit UL SRS” is transferred from LMF to gNBs for Multi-RTT, UL-TDOA and UL-AoA, respectively. However, a UE does not need e.g. PCI to transmit UL SRS. The sentence is changed to “PCI, GCI, and TRP ID of the TRP to receive UL SRS“. 8. The “Assistance Data Delivery” procedure in NRPPa is defined as “TRP information exchange” in the NRPPa baseline (R3-201471), and not as “Assistance Data Request/Response”. The Figures are updated accordingly. 9. The “TRP information exchange” procedure is added to UL TDOA and UL AoA positioning in clause 8.13.3.2.1 and 8.14.3.2.1, respectively. 10. Other minor corrections and alignments. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **x** | Other core specifications | | | |  | | |
| ***affected:*** | |  | **x** | Test specifications | | | |  | | |
| ***(show related CRs)*** | |  | **x** | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | | V2:Update of change #7;  Addition of change #8. | | | | | | | | |

# 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 23.501 "System Architecture for the 5G System; Stage 2".

[3] 3GPP TS 22.071: "Location Services (LCS); Service description, Stage 1".

[4] 3GPP TS 23.032: "Universal Geographical Area Description (GAD)".

[5] IS-GPS-200, Revision D, Navstar GPS Space Segment/Navigation User Interfaces, March 7th, 2006.

[6] IS-GPS-705, Navstar GPS Space Segment/User Segment L5 Interfaces, September 22, 2005.

[7] IS-GPS-800, Navstar GPS Space Segment/User Segment L1C Interfaces, September 4, 2008.

[8] Galileo OS Signal in Space ICD (OS SIS ICD), Draft 0, Galileo Joint Undertaking, May 23rd, 2006.

[9] Global Navigation Satellite System GLONASS Interface Control Document, Version 5, 2002.

[10] IS-QZSS, Quasi Zenith Satellite System Navigation Service Interface Specifications for QZSS, Ver.1.0, June 17, 2008.

[11] Specification for the Wide Area Augmentation System (WAAS), US Department of Transportation, Federal Aviation Administration, DTFA01-96-C-00025, 2001.

[12] RTCM 10402.3, RTCM Recommended Standards for Differential GNSS Service (v.2.3), August 20, 2001.

[13] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[14] 3GPP TS 38.331: "NR Radio Resource Control (RRC) protocol specification".

[15] OMA-AD-SUPL-V2\_0: "Secure User Plane Location Architecture Approved Version 2.0".

[16] OMA-TS-ULP-V2\_0\_4: "UserPlane Location Protocol Approved Version 2.0.4".

[17] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".

[18] 3GPP TS 36.302: "Evolved Universal Terrestrial Radio Access (E-UTRA); Services provided by the physical layer".

[19] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)"

[20] BDS-SIS-ICD-2.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.0)", December 2013.

[21] IEEE 802.11: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications"

[22] Bluetooth Special Interest Group: "Bluetooth Core Specification v4.2", December 2014.

[23] ATIS-0500027: "Recommendations for Establishing Wide Scale Indoor Location Performance", May 2015.

[24] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".

[25] 3GPP TS 36.305: "Stage 2 functional specification of User Equipment (UE) positioning in E‑UTRA".

[26] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[27] 3GPP TS 38.455: "NG-RAN; NR Positioning Protocol A (NRPPa)".

[28] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[29] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[30] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[31] RTCM 10403.3, "RTCM Recommended Standards for Differential GNSS Services (v.3.3)", October 7, 2016.

[32] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[33] 3GPP TS 29.572: "Location Management Services; Stage 3".

[34] BDS-SIS-ICD-B1C-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C (Version 1.0)", December, 2017

[35] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[36] IS-QZSS-L6-001, Quasi-Zenith Satellite System Interface Specification – Centimetre Level Augmentation Service, Cabinet Office, November 5, 2018.

[37] 3GPP TS 38.215: "NR; Physical layer – Measurements".

[38] 3GPP TS 38.401: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NG-RAN; Architecture description".

[xx] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

# 3 Definitions, symbols 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].

As used in this document, the suffixes "-based" and "-assisted" refer respectively to the node that is responsible for making the positioning calculation (and which may also provide measurements) and a node that provides measurements (but which does not make the positioning calculation). Thus, an operation in which measurements are provided by the UE to the LMF to be used in the computation of a position estimate is described as "UE-assisted" (and could also be called "LMF-based"), while one in which the UE computes its own position is described as "UE-based".

**Transmission Point (TP)**: A set of geographically co-located transmit antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one DL PRS-only TP. Transmission Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a DL PRS-only TP, etc. One cell can include one or multiple transmission points. For a homogeneous deployment, each transmission point may correspond to one cell.

**Reception Point (RP)**: A set of geographically co-located receive antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one UL SRS-only RP. Reception Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a UL SRS-only RP, etc. One cell can include one or multiple reception points. For a homogeneous deployment, each reception point may correspond to one cell.

**PRS-only TP**: A TP which only transmits PRS signals for PRS-based TBS positioning and is not associated with a cell.

**Transmission-Reception Point (TRP)**: A set of geographically co-located antennas (e.g. antenna array (with one or more antenna elements)) supporting TP and/or RP functionality.

## 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].

5GC 5G Core Network

5GS 5G System

A-AoA Azimuth of Arrival

ADR Accumulated Delta Range

AoA Angle of Arrival

AP Access Point

ARP Antenna Reference Point

BDS BeiDou Navigation Satellite System

BSSID Basic Service Set Identifier

CID Cell-ID (positioning method)

CLAS Centimetre Level Augmentation Service

DL-AoD Downlink Angle-of-Departure

DL-TDOA Downlink Time Difference Of Arrival

E-SMLC Enhanced Serving Mobile Location Centre

E-CID Enhanced Cell-ID (positioning method)

ECEF Earth-Centered, Earth-Fixed

ECI Earth-Centered-Inertial

EGNOS European Geostationary Navigation Overlay Service

E-UTRAN Evolved Universal Terrestrial Radio Access Network

FDMA Frequency Division Multiple Access

FKP Flächenkorrekturparameter (Engl: Area Correction Parameters)

GAGAN GPS Aided Geo Augmented Navigation

GLONASS GLObal'naya NAvigatsionnaya Sputnikovaya Sistema (Engl.: Global Navigation Satellite System)

GMLC Gateway Mobile Location Center

GNSS Global Navigation Satellite System

GPS Global Positioning System

GRS80 Geodetic Reference System 1980

HESSID Homogeneous Extended Service Set Identifier

LCS LoCation Services

LMF Location Management Function

LPP LTE Positioning Protocol

MAC Master Auxiliary Concept

MBS Metropolitan Beacon System

MO-LR Mobile Originated Location Request

MT-LR Mobile Terminated Location Request

Multi-RTT Multi-Round Trip Time

NG-C NG Control plane

NG-AP NG Application Protocol

NI-LR Network Induced Location Request

N-RTK Network – Real-Time Kinematic

NRPPa NR Positioning Protocol A

OTDOA Observed Time Difference Of Arrival

PDU Protocol Data Unit

posSIB Positioning SIB

PPP Precise Point Positioning

PPP-RTK Precise Point Positioning – Real-Time Kinematic

PRS Positioning Reference Signal (for E-UTRA)

QZSS Quasi-Zenith Satellite System

RP Reception Point

RRM Radio Resource Management

RSRP Reference Signal Received Power

RSSI Received Signal Strength Indicator

RSTD Reference Signal Time Difference

RTK Real-Time Kinematic

SBAS Space Based Augmentation System

SET SUPL Enabled Terminal

SIB System Information Block

SLP SUPL Location Platform

SRS Sounding Reference Signals

SSID Service Set Identifier

SSR State Space Representation

STEC Slant TEC

SUPL Secure User Plane Location

TADV Timing Advance

TBS Terrestrial Beacon System

TEC Total Electron Content

TP Transmission Point

TRP Transmission-Reception Point

UE User Equipment

UL-RTOA Uplink Relative Time of Arrival

UL-TDOA Uplink Time Difference of Arrival

URA User Range Accuracy

WAAS Wide Area Augmentation System

WGS-84 World Geodetic System 1984

WLAN Wireless Local Area Network

Z-AoA Zenith Angles of Arrival

# 4 Main concepts and requirements

## 4.1 Assumptions and Generalities

The stage 1 description of LCS at the service level is provided in TS 22.071 [3]; the stage 2 LCS functional description, including the LCS system architecture and message flows, is provided in TS 23.501 [2], TS 23.502 [26] and TS 23.273 [35].

Positioning functionality provides a means to determine the geographic position and/or velocity of the UE based on measuring radio signals. The position information may be requested by and reported to a client (e.g., an application) associated with the UE, or by a client within or attached to the core network. The position information shall be reported in standard formats, such as those for cell-based or geographical co-ordinates, together with the estimated errors (uncertainty) of the position and velocity of the UE and, if available, the positioning method (or the list of the methods) used to obtain the position estimate.

Restrictions on the geographic shape encoded within the 'position information' parameter may exist for certain LCS client types. The 5GS, including NG-RAN, shall comply with any shape restrictions defined in 5GS and, in a particular country, with any shape restrictions defined for a specific LCS client type in relevant national standards. For example, in the US, national standard J-STD-036-C-2 restricts the geographic shape for an emergency services LCS client to minimally either an "ellipsoid point" or an "ellipsoid point with uncertainty circle" as defined in TS 23.032 [4].

It shall be possible for the majority of the UEs within a network to use the LCS feature without compromising the radio transmission or signalling capabilities of the NG-RAN.

The uncertainty of the position measurement shall be network-implementation-dependent, at the choice of the network operator. The uncertainty may vary between networks as well as from one area within a network to another. The uncertainty may be hundreds of metres in some areas and only a few metres in others. In the event that a particular position measurement is provided through a UE-assisted process, the uncertainty may also depend on the capabilities of the UE. In some jurisdictions, there is a regulatory requirement for location service accuracy that is part of an emergency service. Further details of the accuracy requirements can be found in TS 22.071 [3].

The uncertainty of the position information is dependent on the method used, the position of the UE within the coverage area and the activity of the UE. Several design options of the NG-RAN system (e.g., size of cell, adaptive antenna technique, pathloss estimation, timing accuracy, ng-eNB and gNB surveys) shall allow the network operator to choose a suitable and cost-effective UE positioning method for their market.

There are many different possible uses for the positioning information. The positioning functions may be used internally by the 5GS, by value-added network services, by the UE itself or through the network, and by "third party" services. The feature may also be used by an emergency service (which may be mandated or "value-added"), but the location service is not exclusively for emergencies.

Design of the NG-RAN positioning capability as documented in this specification includes position methods, protocols and procedures that are either adapted from capabilities already supported for E-UTRAN, UTRAN and GERAN, or created separately from first principles. In contrast to GERAN and UTRAN but similarly to E-UTRAN, the NG-RAN positioning capabilities are intended to be forward compatible to other access types and other position methods, in an effort to reduce the amount of additional positioning support needed in the future. This goal also extends to user plane location solutions such as OMA SUPL ([15], [16]), for which NG-RAN positioning capabilities are intended to be compatible where appropriate.

As a basis for the operation of UE Positioning in NG-RAN, the following assumptions apply:

- both TDD and FDD will be supported;

- the provision of the UE Positioning function in NG-RAN and 5GC is optional through support of the specified method(s) in the ng-eNB, gNB and the LMF;

- UE Positioning is applicable to any target UE, whether or not the UE supports LCS, but with restrictions on the use of certain positioning methods depending on UE capability (e.g. as defined within the LPP protocol);

- the positioning information may be used for internal system operations to improve system performance;

- the UE Positioning architecture and functions shall include the option to accommodate several techniques of measurement and processing to ensure evolution to follow changing service requirements and to take advantage of advancing technology.

## 4.2 Role of UE Positioning Methods

The NG-RAN may utilise one or more positioning methods in order to determine the position of an UE.

Positioning the UE involves two main steps:

- signal measurements; and

- position estimate and optional velocity computation based on the measurements.

The signal measurements may be made by the UE or by the serving ng-eNB or gNB. The basic signals measured for terrestrial position methods are typically the LTE radio transmissions; however, other methods may make use of other transmissions such as general radio navigation signals including those from Global Navigation Satellites Systems (GNSSs).

The positioning function should not be limited to a single method or measurement. That is, it should be capable of utilising other standard methods and measurements, as such methods and measurements are available and appropriate, to meet the required service needs of the location service client. This additional information could consist of readily available E-UTRAN or NG-RAN measurements.

The position estimate computation may be made by the UE or by the LMF.

## 4.3 Standard UE Positioning Methods

### 4.3.1 Introduction

The standard positioning methods supported for NG-RAN access are:

- network-assisted GNSS methods;

- observed time difference of arrival (OTDOA) positioning based on LTE signals;

- enhanced cell ID methods based on LTE signals;

- WLAN positioning;

- Bluetooth positioning;

- terrestrial beacon system (TBS) positioning;

- sensor based methods:

- barometric Pressure Sensor;

- motion sensor.

- NR enhanced cell ID methods (NR E-CID) based on NR signals;

- Multi-Round Trip Time Positioning (Multi-RTT based on NR signals);

- Downlink Angle-of-Departure (DL-AoD) based on NR signals;

- Downlink Time Difference of Arrival (DL-TDOA) based on NR signals;

- Uplink Time Difference of Arrival (UL-TDOA) based on NR signals;

- Uplink Angle of Arrival (UL-AoA), including the Azimuth of Arrival (A-AoA) and the Zenith of Arrival (Z-AoA) based on NR signals.

Hybrid positioning using multiple methods from the list of positioning methods above is also supported.

Standalone mode (e.g. autonomous, without network assistance) using one or more methods from the list of positioning methods above is also supported.

These positioning methods may be supported in UE-based, UE-assisted/LMF-based, and NG-RAN node assisted versions. Table 4.3.1-1 indicates which of these versions are supported in this version of the specification for the standardised positioning methods.

Table 4.3.1-1: Supported versions of UE positioning methods

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Method | UE-based | UE-assisted, LMF-based | NG-RAN node assisted | SUPL |
| A-GNSS | Yes | Yes | No | Yes (UE-based and UE-assisted) |
| OTDOA Note1, Note 2 | No | Yes | No | Yes (UE-assisted) |
| E-CID Note 4 | No | Yes | Yes | Yes for E-UTRA (UE-assisted) |
| Sensor | Yes | Yes | No | No |
| WLAN | Yes | Yes | No | Yes |
| Bluetooth | No | Yes | No | No |
| TBS Note 5 | Yes | Yes | No | Yes (MBS) |
| DL-TDOA | Yes | Yes | No | No |
| DL-AoD | Yes | Yes | No | No |
| Multi-RTT | No | Yes | Yes | No |
| NR E-CID | No | Yes | FFS | No |
| UL-TDOA | No | No | Yes | No |
| UL-AoA | No | No | Yes | No |
| NOTE 1: This includes TBS positioning based on PRS signals.  NOTE 2: In this version of the specification only OTDOA based on LTE signals is supported.  NOTE 3: Void  NOTE 4: This includes Cell-ID for NR method.  NOTE 5: In this version of the specification only for TBS positioning based on MBS signals.  NOTE 6: Void | | | | |

Sensor, WLAN, Bluetooth, and TBS positioning methods based on MBS signals are also supported in standalone mode, as described in the corresponding clauses.

### 4.3.2 Network-assisted GNSS methods

These methods make use of UEs that are equipped with radio receivers capable of receiving GNSS signals.

Examples of GNSS include GPS, Modernized GPS, Galileo, GLONASS, Space Based Augmentation Systems (SBAS), Quasi Zenith Satellite System (QZSS), and BeiDou Navigation Satellite System (BDS).

In this concept, different GNSSs (e.g. GPS, Galileo, etc.) can be used separately or in combination to determine the location of a UE.

The operation of the network-assisted GNSS methods is described in clause 8.1.

### 4.3.3 OTDOA positioning

The OTDOA positioning method makes use of the measured timing of downlink signals received from multiple TPs, comprising eNBs, ng-eNBs and PRS-only TPs, at the UE. The UE measures the timing of the received signals using assistance data received from the positioning server, and the resulting measurements are used to locate the UE in relation to the neighbouring TPs.

The operation of the OTDOA method is described in clause 8.2.

### 4.3.4 Enhanced Cell ID methods

In the Cell ID (CID) positioning method, the position of an UE is estimated with the knowledge of its serving ng-eNB, gNB and cell. The information about the serving ng-eNB, gNB and cell may be obtained by paging, registration, or other methods.

Enhanced Cell ID (E‑CID) based on LTE signals positioning refers to techniques which use additional UE measurements and/or NG-RAN radio resource and other measurements to improve the UE location estimate.

Although E-CID based on LTE signals positioning may utilise some of the same measurements as the measurement control system in the RRC protocol, the UE generally is not expected to make additional measurements for the sole purpose of positioning; i.e., the positioning procedures do not supply a measurement configuration or measurement control message, and the UE reports the measurements that it has available rather than being required to take additional measurement actions.

In cases with a requirement for close time coupling between UE and ng-eNB measurements (e.g., TADV type 1 and UE E-UTRA Rx-Tx time difference), the ng-eNB configures the appropriate RRC measurements and is responsible for maintaining the required coupling between the measurements.

In the case of a serving gNB, E‑CID based on LTE signals positioning can be supported using E-UTRA measurements provided by a UE to the serving gNB.

The operation of the Enhanced Cell ID based on LTE signals method is described in clause 8.3.

### 4.3.5 Barometric pressure sensor positioning

The barometric pressure sensor method makes use of barometric sensors to determine the vertical component of the position of the UE. The UE measures barometric pressure, optionally aided by assistance data, to calculate the vertical component of its location or to send measurements to the positioning server for position calculation.

This method should be combined with other positioning methods to determine the 3D position of the UE.

The operation of the Barometric pressure sensor positioning method is described in clause 8.4.

### 4.3.6 WLAN positioning

The WLAN positioning method makes use of the WLAN measurements (AP identifiers and optionally other measurements) and databases to determine the location of the UE. The UE measures received signals from WLAN [21] access points, optionally aided by assistance data, to send measurements to the positioning server for position calculation. Using the measurement results and a references database, the location of the UE is calculated.

Alternatively, the UE makes use of WLAN measurements and optionally WLAN AP assistance data provided by the positioning server, to determine its location.

The operation of the WLAN positioning method is described in clause 8.5.

### 4.3.7 Bluetooth positioning

The Bluetooth positioning method makes use of Bluetooth measurements (beacon identifiers and optionally other measurements) to determine the location of the UE. The UE measures received signals from Bluetooth [22] beacons. Using the measurement results and a references database, the location of the UE is calculated. The Bluetooth methods may be combined with other positioning methods (e.g. WLAN) to improve positioning accuracy of the UE.

The operation of the Bluetooth positioning method is described in clause 8.6.

### 4.3.8 TBS positioning

A Terrestrial Beacon System (TBS) consists of a network of ground-based transmitters, broadcasting signals only for positioning purposes. The current type of TBS positioning signals are the MBS (Metropolitan Beacon System) signals [23] and Positioning Reference Signals (PRS) (TS 36.211 [24]). The UE measures received TBS signals, optionally aided by assistance data, to calculate its location or to send measurements to the positioning server for position calculation.

The operation of the TBS positioning method based on MBS signals is described in clause 8.7.

TBS positioning based on PRS signals is part of OTDOA positioning and described in clause 8.2.

### 4.3.9 Motion sensor positioning

The motion sensor method makes use of different sensors such as accelerometers, gyros, magnetometers, to calculate the displacement of UE. The UE estimates a relative displacement based upon a reference position and/or reference time. UE sends a report comprising the determined relative displacement which can be used to determine the absolute position.

This method should be used with other positioning methods for hybrid positioning.

The operation of the sensor positioning method is described in clause 8.8.

### 4.3.10 NR Enhanced Cell ID methods

NR Enhanced Cell ID (NR E‑CID) positioning refers to techniques which use additional UE measurements and/or NR radio resource and other measurements to improve the UE location estimate.

Although NR E-CID positioning may utilise some of the same measurements as the measurement control system in the RRC protocol, the UE generally is not expected to make additional measurements for the sole purpose of positioning; i.e., the positioning procedures do not supply a measurement configuration or measurement control message, and the UE reports the measurements that it has available rather than being required to take additional measurement actions.

The operation of the NR Enhanced Cell ID method is described in clause 8.9.

### 4.3.11 Multi-RTT positioning

The Multi-RTT positioning method makes use of the UE Rx-Tx measurements and DL PRS RSRP of downlink signals received from multiple TRPs, measured by the UE and the measured gNB Rx-Tx measurements and UL SRS-RSRP at multiple TRPs of uplink signals transmitted from UE.

The UE measures the UE Rx-Tx measurements (and optionally DL PRS RSRP of the received signals) using assistance data received from the positioning server, and the TRPs measure the gNB Rx-Tx measurements (and optionally UL SRS-RSRP of the received signals) using assistance data received from the positioning server. The measurements are used to determine the RTT at the positioning server which are used to estimate the location of the UE.

The operation of the Multi-RTT positioning method is described in clause 8.10.

### 4.3.12 DL AoD positioning

The DL AoD positioning method makes use of the measured DL PRS RSRP of downlink signals received from multiple TPs, at the UE. The UE measures the DL PRS RSRP of the received signals using assistance data received from the positioning server, and the resulting measurements are used along with other configuration information to locate the UE in relation to the neighbouring TPs.

The operation of the DL AoD positioning method is described in clause 8.11.

### 4.3.13 DL TDOA positioning

The DL TDOA positioning method makes use of the DL RSTD (and optionally DL PRS RSRP) of downlink signals received from multiple TPs, at the UE. The UE measures the DL RSTD (and optionally DL PRS RSRP) of the received signals using assistance data received from the positioning server, and the resulting measurements are used along with other configuration information to locate the UE in relation to the neighbouring TPs.

The operation of the DL TDOA positioning method is described in clause 8.12.

### 4.3.14 UL TDOA positioning

The UL TDOA positioning method makes use of the UL RTOA (and optionally UL SRS-RSRP) at multiple RPs of uplink signals transmitted from UE. The RPs measure the UL RTOA (and optionally UL SRS-RSRP) of the received signals using assistance data received from the positioning server, and the resulting measurements are used along with other configuration information to estimate the location of the UE.

The operation of the UL TDOA positioning method is described in clause 8.13.

### 4.3.15 UL AoA

The UL AoA positioning method makes use of the measured azimuth and zenith of arrival at multiple RPs of uplink signals transmitted from the UE. The RPs measure A-AoA and Z-AoA of the received signals using assistance data received from the positioning server, and the resulting measurements are used along with other configuration information to estimate the location of the UE.

The operation of the UL AoA positioning method is escribed in clause 8.14.

# 5 NG-RAN UE Positioning Architecture

## 5.1 Architecture

Figure 5.1-1 shows the architecture in 5GS applicable to positioning of a UE with NR or E-UTRA access.

The AMF receives a request for some location service associated with a particular target UE from another entity (e.g., GMLC or UE) or the AMF itself decides to initiate some location service on behalf of a particular target UE (e.g., for an IMS emergency call from the UE) as described in TS 23.502 [26] and TS 23.273 [35]. The AMF then sends a location services request to an LMF. The LMF processes the location services request which may include transferring assistance data to the target UE to assist with UE-based and/or UE-assisted positioning and/or may include positioning of the target UE. The LMF then returns the result of the location service back to the AMF (e.g., a position estimate for the UE. In the case of a location service requested by an entity other than the AMF (e.g., a GMLC or UE), the AMF returns the location service result to this entity.

An NG-RAN node may control several TRPs/TPs, such as remote radio heads, or DL PRS-only TPs for support of PRS-based TBS.

An LMF may have a signalling connection to an E-SMLC which may enable an LMF to access information from E‑UTRAN (e.g. to support the OTDOA for E-UTRA positioning method using downlink measurements obtained by a target UE of signals from eNBs and/or PRS-only TPs in E-UTRAN). Details of the signalling interaction between an LMF and E-SMLC are outside the scope of this specification.

An LMF may have a signalling connection to an SLP. The SLP is the SUPL entity responsible for positioning over the user plane. Further details of user-plane positioning are provided in [15][16].



Figure 5.1-1: UE Positioning Architecture applicable to NG-RAN

NOTE 1: The gNB and ng-eNB may not always both be present.

NOTE 2: Void

## 5.2 UE Positioning Operations

To support positioning of a target UE and delivery of location assistance data to a UE with NG-RAN access in 5GS, location related functions are distributed as shown in the architecture in Figure 5.1-1 and as clarified in greater detail in TS 23.501 [2] and TS 23.273 [35]. The overall sequence of events applicable to the UE, NG-RAN and LMF for any location service is shown in Figure 5.2-1.

Note that when the AMF receives a Location Service Request in case of the UE is in CM-IDLE state, the AMF performs a network triggered service request as defined in TS 23.502 [26] and TS 23.273 [35] in order to establish a signalling connection with the UE and assign a specific serving gNB or ng-eNB. The UE is assumed to be in connected mode before the beginning of the flow shown in the Figure 5.2-1; that is, any signalling that might be required to bring the UE to connected mode prior to step 1a is not shown. The signalling connection may, however, be later released (e.g. by the NG-RAN node as a result of signalling and data inactivity) while positioning is still ongoing.



Figure 5.2-1: Location Service Support by NG-RAN

1a. Either: some entity in the 5GC (e.g. GMLC) requests some location service (e.g. positioning) for a target UE to the serving AMF.

1b. Or: the serving AMF for a target UE determines the need for some location service (e.g. to locate the UE for an emergency call).

1c. Or: the UE requests some location service (e.g. positioning or delivery of assistance data) to the serving AMF at the NAS level.

2. The AMF transfers the location service request to an LMF.

3a. The LMF instigates location procedures with the serving and possibly neighbouring ng-eNB or gNB in the NG-RAN – e.g. to obtain positioning measurements or assistance data.

3b. In addition to step 3a or instead of step 3a, the LMF instigates location procedures with the UE – e.g. to obtain a location estimate or positioning measurements or to transfer location assistance data to the UE.

4. The LMF provides a location service response to the AMF and includes any needed results – e.g. success or failure indication and, if requested and obtained, a location estimate for the UE.

5a. If step 1a was performed, the AMF returns a location service response to the 5GC entity in step 1a and includes any needed results – e.g. a location estimate for the UE.

5b. If step 1b occurred, the AMF uses the location service response received in step 4 to assist the service that triggered this in step 1b (e.g. may provide a location estimate associated with an emergency call to a GMLC).

5c. If step 1c was performed, the AMF returns a location service response to the UE and includes any needed results – e.g. a location estimate for the UE.

Location procedures applicable to NG-RAN occur in steps 3a and 3b in Figure 5.2-1 and are defined in greater detail in this specification. Other steps in Figure 5.2-1 are applicable only to the 5GC and are described in greater detail and in TS 23.502 [26] and TS 23.273 [35].

Steps 3a and 3b can involve the use of different position methods to obtain location related measurements for a target UE and from these compute a location estimate and possibly additional information like velocity. Positioning methods supported in this release are summarized in clause 4.3 and described in detail in clause 8.

The case that the NG-RAN node functions as an LCS client is not supported in this version of the specification.

## 5.3 NG-RAN Positioning Operations

### 5.3.1 General NG-RAN Positioning Operations

Separately from location service support for particular UEs, an LMF may interact with elements in the NG-RAN in order to obtain measurement information to help assist one or more position methods for all UEs. An LMF may also interact with NG-RAN node to provide assistance data information for broadcasting.

### 5.3.2 OTDOA Positioning Support

An LMF can interact with any ng-eNB reachable from any of the AMFs with signalling access to the LMF in order to obtain location related information to support the OTDOA for E-UTRA positioning method, including PRS-based TBS for E-UTRA. The information can include timing information for the TP in relation to either absolute GNSS time or timing of other TPs and information about the supported cells and TPs including PRS schedule.

Signalling access between the LMF and ng-eNB may be via any AMF with signalling access to both the LMF and ng‑eNB. In the case of an ng-eNB with no signalling access to an AMF, signalling access between the LMF and ng‑eNB may be via any AMF with signalling access to both the LMF and a gNB with signalling access to the ng-eNB.

### 5.3.3 Assistance Information Broadcast Support

An LMF can interact with any NG-RAN node reachable from any of the AMFs with signalling access to the LMF in order to provide assistance data information for broadcasting. The information can include positioning System Information Blocks (posSIBs) together with assistance information meta data and broadcast periodicity.

Signalling access between the LMF and NG-RAN node is via any AMF with signalling access to both the LMF and NG-RAN node.

### 5.3.4 NR RAT-Dependent Positioning Support

An LMF can interact with any gNB reachable from any of the AMFs with signalling access to the LMF in order to obtain location related information to support the NR RAT-Dependent positioning methods. The information can include timing information for the TRP in relation to either absolute GNSS time or timing of other TRPs and information about the supported cells and TRPs including PRS schedule.

Signalling access between the LMF and gNB may be via any AMF with signalling access to both the LMF and gNB.

## 5.4 Functional Description of Elements Related to UE Positioning in NG-RAN

### 5.4.1 User Equipment (UE)

The UE may make measurements of downlink signals from NG-RAN and other sources such as E-UTRAN, different GNSS and TBS systems, WLAN access points, Bluetooth beacons, UE barometric pressure and motion sensors. The measurements to be made will be determined by the chosen positioning method.

The UE may also contain LCS applications, or access an LCS application either through communication with a network accessed by the UE or through another application residing in the UE. This LCS application may include the needed measurement and calculation functions to determine the UE's position with or without network assistance. This is outside of the scope of this specification.

The UE may also, for example, contain an independent positioning function (e.g., GPS) and thus be able to report its position, independent of the NG-RAN transmissions. The UE with an independent positioning function may also make use of assistance information obtained from the network.

### 5.4.2 gNB

The gNB is a network element of NG-RAN that may provide measurement information for a target UE and communicates this information to an LMF.

To support NR RAT-Dependent positioning, the gNB may provide measurement results for position estimation and makes measurements of radio signals for a target UE and communicates these measurements to an LMF. A gNB may serve several TRPs, including for example remote radio heads, and UL-SRS only RPs and DL PRS-only TPs.

A gNB may broadcast assistance data information, received from an LMF, in positioning System Information messages.

### 5.4.3 ng-eNB

The ng-eNB is a network element of NG-RAN that may provide measurement results for position estimation and makes measurements of radio signals for a target UE and communicates these measurements to an LMF.

The ng-eNB makes its measurements in response to requests from the LMF (on demand or periodically).

An ng-eNB may serve several TPs, including for example remote radio heads and PRS-only TPs for PRS-based TBS positioning for E-UTRA.

An ng-eNB may broadcast assistance data information, received from an LMF, in positioning System Information messages.

### 5.4.4 Location Management Function (LMF)

The LMF manages the support of different location services for target UEs, including positioning of UEs and delivery of assistance data to UEs. The LMF may interact with the serving gNB or serving ng-eNB for a target UE in order to obtain position measurements for the UE, including uplink measurements made by an NG-RAN and downlink measurements made by the UE that were provided to an NG-RAN as part of other functions such as for support of handover.

The LMF may interact with a target UE in order to deliver assistance data if requested for a particular location service, or to obtain a location estimate if that was requested.

The LMF may interact with multiple NG-RAN nodes to provide assistance data information for broadcasting. The assistance data information for broadcast may optionally be segmented and/or ciphered by the LMF. The LMF may also interact with AMFs to provide ciphering key data information to the AMF as described in greater detail in TS 23.273 [35].

For positioning of a target UE, the LMF decides on the position methods to be used, based on factors that may include the LCS Client type, the required QoS, UE positioning capabilities, gNB positioning capabilities and ng-eNB positioning capabilities. The LMF then invokes these positioning methods in the UE, serving gNB and/or serving ng‑eNB. The positioning methods may yield a location estimate for UE-based position methods and/or positioning measurements for UE-assisted and network-based position methods. The LMF may combine all the received results and determine a single location estimate for the target UE (hybrid positioning). Additional information like accuracy of the location estimate and velocity may also be determined.

# 6 Signalling protocols and interfaces

## 6.1 Network interfaces supporting positioning operations

### 6.1.1 General LCS control plane architecture

The general LCS control plane architecture in the 5GS applicable to a target UE with NG-RAN access is defined in TS 23.501 [2] and TS 23.273 [35].

### 6.1.2 NR-Uu interface

The NR-Uu interface, connecting the UE to the gNB over the air, is used as one of several transport links for the NR positioning protocol(s) for a target UE with NR access to NG-RAN.

### 6.1.3 LTE-Uu interface

The LTE-Uu interface, connecting the UE to the ng-eNB over the air, is used as one of several transport links for the LTE positioning protocol(s) for a target UE with LTE access to NG-RAN.

### 6.1.4 NG-C interface

The NG-C interface between the gNB and the AMF and between the ng-eNB and the AMF is transparent to all UE-positioning-related procedures. It is involved in these procedures only as a transport link for the NR positioning protocol(s).

For gNB related positioning procedures, the NG-C interface transparently transports both positioning requests from the LMF to the gNB and positioning results from the gNB to the LMF.

For ng-eNB related positioning procedures, the NG-C interface transparently transports both positioning requests from the LMF to the ng-eNB and positioning results from the ng-eNB to the LMF.

For delivery of broadcast assistance data information, the NG-C interface transparently transports both the assistance data information from the LMF to the NG-RAN node for broadcasting and the feedback information on assistance information broadcasting from the NG-RAN node to the LMF. The NG-C interface is also used by an AMF to transparently transport ciphering keys via NG-RAN node to UEs using a NAS message. The ciphering keys are used to decipher broadcast assistance data information, if the broadcast assistance data information is ciphered.

### 6.1.5 NLs interface

The NLs interface, between the LMF and the AMF, is transparent to all UE related, gNB related and ng-eNB related positioning procedures. It is used only as a transport link for the LTE Positioning Protocols LPP and NRPPa.

### 6.1.6 F1 interface

The F1 interface is used to support the exchange of positioning information between the gNB-DU and the gNB-CU; it is also used as a transport link for the LPP.

## 6.2 UE-terminated protocols

### 6.2.1 LTE Positioning Protocol (LPP)

The LTE Positioning Protocol (LPP) is terminated between a target device (the UE in the control-plane case or SET in the user-plane case) and a positioning server (the LMF in the control-plane case or SLP in the user-plane case). It may use either the control- or user-plane protocols as underlying transport. In this specification, only control plane use of LPP is defined. User plane support of LPP is defined in [15] and [16].

LPP messages are carried as transparent PDUs across intermediate network interfaces using the appropriate protocols (e.g., NGAP over the NG-C interface, NAS/RRC over the LTE-Uu and NR-Uu interfaces). The LPP protocol is intended to enable positioning for NR and LTE using a multiplicity of different position methods, while isolating the details of any particular positioning method and the specifics of the underlying transport from one another.

The protocol operates on a transaction basis between a target device and a server, with each transaction taking place as an independent procedure. More than one such procedure may be in progress at any given moment. An LPP procedure may involve a request/response pairing of messages or one or more "unsolicited" messages. Each procedure has a single objective (e.g., transfer of assistance data, exchange of LPP related capabilities, or positioning of a target device according to some QoS and use of one or more positioning methods). Multiple procedures, in series and/or in parallel, can be used to achieve more complex objectives (e.g., positioning of a target device in association with transfer of assistance data and exchange of LPP related capabilities). Multiple procedures also enable more than one positioning attempt to be ongoing at the same time (e.g., to obtain a coarse location estimate with low delay while a more accurate location estimate is being obtained with higher delay).

An LPP session is defined between a positioning server and the target device, the details of its relation with transactions are described in clause 4.1.2 of TS 36.355 [19].

For the 3GPP 5GS Control Plane solution defined in TS 23.501 [2], TS 23.502 [26] and TS 23.273 [35], the UE is the target device and the LMF is the server. For SUPL 2.0 support, the SUPL Enabled Terminal (SET) is the target device and the SUPL Location Platform (SLP) is the server. The operations controlled through LPP are described further in clause 7.1.

LPP defined data structures for assistance data information are reused for supporting RRC broadcast of assistance data information which are embedded in positioning SIBs. This enables broadcast assistance data using the same data structures which are used for point to point location.

### 6.2.2 Radio Resource Control (RRC) for NR

The RRC protocol for NR is terminated between the gNB and the UE. It provides transport for LPP messages over the NR-Uu interface.

In addition to providing transport for LPP messages over the NR-Uu interface, it supports transfer of measurements that may be used for positioning purposes through the existing measurement systems specified in TS 38.331 [14].

The RRC protocol for NR also supports broadcasting of assistance data via positioning System Information messages.

The RRC protocol for NR is also used to configure UEs with sounding reference signals (SRS) to support UL positioning.

### 6.2.3 Radio Resource Control (RRC) for LTE

The RRC protocol for LTE is terminated between the ng-eNB and the UE. In addition to providing transport for LPP messages over the LTE-Uu interface, it supports transfer of measurements that may be used for positioning purposes through the existing measurement systems specified in TS 36.331 [13].

The RRC protocol for LTE also supports broadcasting of assistance data via positioning System Information messages.

### 6.2.4 Medium Access Control (MAC) for NR

The MAC protocol for NR supports activation and deactivation of configured semi-persistent SRS resource sets as specified in TS 38.321 [xx] to support UL positioning.

## 6.3 NG-RAN Node terminated protocols

### 6.3.1 NR Positioning Protocol A (NRPPa)

The NR Positioning Protocol A (NRPPa) carries information between the NG-RAN Node and the LMF. It is used to support the following positioning functions:

- E-CID for E-UTRA where measurements are transferred from the ng-eNB to the LMF.

- Data collection from ng-eNB's for support of OTDOA positioning for E-UTRA.

- Cell-ID and Cell Portion ID retrieval from gNB's for support of NR Cell ID positioning method.

- Exchange of information between LMF and NG-RAN node for the purpose of assistance data broadcasting.

- NR Multi-RTT where measurements are transferred from the gNB to the LMF.

- NR UL-AoA where measurements are transferred from the gNB to the LMF.

- NR UL-TDOA where measurements are transferred from the gNB to the LMF.

- Data collection from gNBs for support of DL-TDOA, DL-AoD, Multi-RTT, UL-TDOA, UL-AoA.

The NRPPa protocol is transparent to the AMF. The AMF routes the NRPPa PDUs transparently based on a Routing ID corresponding to the involved LMF over NG-C interface without knowledge of the involved NRPPa transaction. It carries the NRPPa PDUs over NG-C interface either in UE associated mode or non-UE associated mode.

In case of a split gNB, the NRPPa protocol is terminated at the gNB-CU.

### 6.3.2 NG Application Protocol (NGAP)

The NGAP protocol, terminated between the AMF and the NG-RAN Node, is used as transport for LPP and NRPPa messages over the NG-C interface. The NGAP protocol is also used to instigate and terminate NG-RAN Node related positioning procedures.

## 6.4 Signalling between an LMF and UE

### 6.4.1 Protocol Layering

Figure 6.4.1-1 shows the protocol layering used to support transfer of LPP messages between an LMF and UE. The LPP PDU is carried in NAS PDU between the AMF and the UE.



Figure 6.4.1-1: Protocol Layering for LMF to UE Signalling

### 6.4.2 LPP PDU Transfer

Figure 6.4.2-1 shows the transfer of an LPP PDU between an LMF and UE, in the network- and UE-triggered cases. These two cases may occur separately or as parts of a single more complex operation.



Figure 6.4.2-1: LPP PDU transfer between LMF and UE (network- and UE-triggered cases)

1. Steps 1 to 4 may occur before, after, or at the same time as steps 5 to 8. Steps 1 to 4 and steps 5 to 8 may also be repeated. Steps 1 to 4 are triggered when the LMF needs to send an LPP message to the UE as part of some LPP positioning activity. The LMF then invokes the Namf\_Communication \_N1N2MessageTransfer service operation towards the AMF to request the transfer of a LPP PDU to the UE. The service operation includes the LPP PDU together with the LCS Correlation ID in the N1 Message Container as defined in TS 29.518 [29].

2. If the UE is in CM-IDLE state (e.g. if the NG connection was previously released due to data and signalling inactivity), the AMF initiates a network triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the UE and assign a serving NG-RAN node.

3. The AMF includes the LPP PDU in the payload container of a DL NAS Transport message, and a Routing Identifier identifying the LMF in the Additional Information of the DL NAS Transport message defined in TS 24.501 [29]. The AMF then sends the DL NAS Transport message to the serving NG-RAN Node in an NGAP Downlink NAS Transport message defined in TS 38.413 [30]. The AMF need not retain state information for this transfer; it can treat any response in step 7 as a separate non-associated transfer.

4. The NG-RAN Node forwards the DL NAS Transport message to the UE in an RRC DL Information Transfer message.

5. Steps 5 to 8 are triggered when the UE needs to send an LPP PDU to the LMF as part of some LPP positioning activity. If the UE is in CM-IDLE state, the UE instigates a UE triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the AMF and assign a serving NG-RAN node.

6. The UE includes the LPP PDU in the payload container of an UL NAS Transport message, and the Routing Identifier, which has been received in step 4, in the Additional Information of the UL NAS Transport message defined in TS 24.501 [29]. The UE then sends the UL NAS Transport message to the serving NG-RAN node in an RRC UL Information Transfer message.

7. The NG-RAN node forwards the UL NAS Transport Message to the AMF in an NGAP Uplink NAS Transport message.

8. The AMF invokes the Namf\_Communication\_N1MessageNotify service operation towards the LMF indicated by the Routing Identifier received in step 7. The service operation includes the LPP PDU received in step 7 together with the LCS Correlation ID in the N1 Message Container as defined in TS 29.518 [28].

## 6.5 Signalling between an LMF and NG-RAN node

### 6.5.1 Protocol Layering

Figure 6.5.1-1 shows the protocol layering used to support transfer of NRPPa PDUs between an LMF and NG-RAN Node.

The NRPPa protocol is transparent to the AMF. The AMF routes the NRPPa PDUs transparently based on a Routing ID which corresponds to the involved LMF node over the NG interface without knowledge of the involved NRPPa transaction. It carries the NRPPa PDUs over NG interface either in UE associated mode or non-UE associated mode.



Figure 6.5.1-1: Protocol Layering for LMF to NG-RAN Signalling

### 6.5.2 NRPPa PDU Transfer for UE Positioning

Figure 6.5.2-1 shows NRPPa PDU transfer between an LMF and NG-RAN Node to support positioning of a particular UE.



Figure 6.5.2-1: NRPPa PDU Transfer between an LMF and NG-RAN node for UE Positioning

1. Steps 1 to 3 are triggered when the LMF needs to send an NRPPa message to the serving NG-RAN Node for a target UE as part of a NRPPa positioning activity. The LMF then invokes the Namf\_Communication\_N1N2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to the serving NG-RAN Node for the UE. The service operation includes the NRPPa PDU together with the LCS Correlation ID in the N2 Message Container as defined in TS 29.518 [28].

2. If the UE is in CM-IDLE state (e.g. if the NG connection was previously released due to data and signalling inactivity), the AMF performs a network triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the UE and assign a serving NG-RAN Node.

3. The AMF forwards the NRPPa PDU to the serving NG-RAN Node in an NGAP Downlink UE Associated NRPPa Transport message over the NG signalling connection corresponding to the UE and includes the Routing ID related to the LMF. The AMF need not retain state information for this transfer – e.g. can treat any response in step 4 as a separate non-associated transfer.

4. Steps 4 and 5 are triggered when a serving NG-RAN Node needs to send an NRPPa message to the LMF for a target UE as part of an NRPPa positioning activity. The NG-RAN Node then sends an NRPPa PDU to the AMF in an NGAP Uplink UE Associated NRPPa Transport message and includes the Routing ID received in step 3.

5. The AMF invokes the Namf\_Communication\_N2InfoNotify service operation towards the LMF indicated by the Routing ID received in step 4. The service operation includes the NRPPa PDU received in step 4 together with the LCS Correlation ID in the N2 Info Container as defined in TS 29.518 [28]. Steps 1 to 5 may be repeated.

### 6.5.3 NRPPa PDU Transfer for Positioning Support

Figure 6.5.3-1 shows NRPPa PDU transfer between an LMF and NG-RAN Node when related to gathering data from the NG-RAN Node for positioning support for all UEs.



Figure 6.5.3-1: NRPPa PDU Transfer between an LMF and NG-RAN for obtaining NG-RAN Data

0. An ng-eNB in the NG-RAN may communicate with several TPs (including PRS-only TPs in case of PRS-based TBS is supported) to configure TPs, obtain TP configuration information, etc.

A gNB in the NG-RAN may communicate with several TRPs (including PRS-only TPs) to configure TRPs, obtain TRP configuration information, etc.

NOTE: NG-RAN–TP/TPR signalling and configuration is outside the scope of this specification.

1. Steps 1 and 2 are triggered when the LMF needs to send an NRPPa message to an NG-RAN Node to obtain data related to the NG-RAN Node, and possibly associated TPs. The LMF invokes the Namf\_Communication\_N1N2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to a NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the target NG-RAN node identity and the NRPPa PDU in the N2 Information Container as defined in TS 29.518 [28].

2. The AMF forwards the NRPPa PDU to the identified NG-RAN Node in an NGAP Downlink Non UE Associated NRPPa Transport message and includes a Routing ID identifying the LMF. The AMF need not retain state information for this transfer – e.g. can treat any response in step 3 as a separate non-associated transfer.

3. Steps 3 and 4 are triggered when an NG-RAN Node needs to send an NRPPa PDU to an LMF containing data applicable to the NG-RAN Node, and possibly associated TPs. The NG-RAN Node then sends an NRPPa PDU to the AMF in an NGAP Uplink Non UE Associated NRPPa Transport message and includes the Routing ID received in step 2.

4. The AMF invokes the Namf\_Communication\_N2InfoNotify service operation towards the LMF indicated by the Routing Identifier received in step 3. The service operation includes the NRPPa PDU received in step 3 in the N2 Info Container as defined in TS 29.518 [28]. Steps 1 to 4 may be repeated.

### 6.5.4 NRPPa PDU Transfer for Assistance Information Broadcast

Figure 6.5.4-1 shows NRPPa PDU transfer between an LMF and NG-RAN node to support broadcast of assistance data.



Figure 6.5.4-1: NRPPa PDU Transfer between an LMF and NG-RAN Node for providing assistance information for broadcasting.

1. Step 1 is triggered when the LMF needs to send new or updated assistance information to an NG-RAN node for broadcasting in positioning system information messages. The LMF invokes the Namf\_Communication\_N1N2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to a NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the target NG-RAN node identity and the NRPPa PDU in the N2 Information Container as defined in TS 29.518 [28].

2. The AMF forwards the NRPPa PDU to the identified NG-RAN node in an NGAP Downlink Non UE Associated NRPPa Transport message and includes the Routing ID identifying the LMF. The AMF need not retain state information for this transfer.

Figure 6.5.4-2 shows NRPPa PDU transfer between an NG-RAN node and LMF for providing feedback to the LMF on assistance data broadcasting.



Figure 6.5.4-2: NRPPa PDU Transfer between an NG-RAN node and LMF for providing feedback on assistance data broadcasting.

1. Step 1 is triggered when an NG-RAN node needs to send an NRPPa PDU to an LMF for providing feedback on assistance data broadcasting. Step 1 may only be triggered if the procedure in Figure 6.5.4-1 has already been performed. The NG-RAN node sends an NRPPa PDU to the AMF in an NGAP Uplink Non UE Associated NRPPa Transport message. The NG-RAN node includes the previously received Routing ID related to the LMF (Figure 6.5.4-1).

2. The AMF invokes the Namf\_Communication\_N2InfoNotify service operation towards the LMF indicated by the Routing identifier received at step 1. The service operation includes the NRPPa PDU received in step 1 in the N2 Info Container as defined in TS 29.518 [28].

## 6.6 Void

# 7 General NG-RAN UE Positioning procedures

## 7.1 General LPP procedures for UE Positioning

### 7.1.1 LPP procedures

Positioning procedures in the NG-RAN are modelled as transactions of the LPP protocol using the procedures defined in this specification. A procedure consists of a single operation of one of the following types:

- Exchange of positioning capabilities;

- Transfer of assistance data;

- Transfer of location information (positioning measurements and/or position estimate);

- Error handling;

- Abort.

Parallel transactions are permitted (i.e. a new LPP transaction may be initiated, while another one is outstanding).

As described in clause 6.2.1, the protocol operates between a "target" and a "server". In the control-plane context, these entities are the UE and LMF respectively; in the SUPL context they are the SET and the SLP. A procedure may be initiated by either the target or the server.

### 7.1.2 Positioning procedures

#### 7.1.2.1 Capability transfer

The capability transfer procedure between a "target" and a "server" is specified in clause 7.1.2.1 of TS 36.305 [25].

#### 7.1.2.2 Assistance data transfer

The assistance data transfer procedure between a "target" and a "server" is specified in clause 7.1.2.2 of TS 36.305 [25].

#### 7.1.2.3 Location information transfer

The location information transfer procedure between a "target" and a "server" is specified in clause 7.1.2.3 of TS 36.305 [25].

#### 7.1.2.4 Multiple transactions

Multiple LPP transactions may be in progress simultaneously as specified in clause 7.1.2.4 of TS 36.305 [25].

#### 7.1.2.5 Sequence of procedures

LPP procedures are not required to occur in any fixed order, in order to provide greater flexibility in positioning. Thus, a UE may request assistance data at any time in order to comply with a previous request for location measurements from the LMF; an LMF may instigate more than one request for location information (e.g., measurements or a location estimate) in case location results from a previous request were not adequate for the requested QoS; and the target device may transfer capability information to the server at any time if not already performed.

Despite the flexibility allowed by LPP, it is expected that procedures will normally occur in the following order:

1. Capability Transfer;

2. Assistance Data Transfer;

3. Location Information Transfer (measurements and/or location estimate).

Specific examples for each positioning method are shown in clause 8.

#### 7.1.2.6 Error handling

The error handling procedure is specified in clause 7.1.2.6 of TS 36.305 [25].

#### 7.1.2.7 Abort

The abort procedure is specified in clause 7.1.2.7 of TS 36.305 [25].

## 7.2 General NRPPa Procedures for UE Positioning

### 7.2.1 NRPPa procedures

Positioning and data acquisition transactions between a LMF and NG-RAN node are modelled by using procedures of the NRPPa protocol. There are two types of NRPPa procedures:

- UE associated procedure, i.e. transfer of information for a particular UE (e.g. positioning measurements);

- Non UE associated procedure, i.e. transfer of information applicable to the NG-RAN node and associated TRPs (e.g. gNB/ng-eNB/TRP timing information).

Parallel transactions between the same LMF and NG-RAN node are supported; i.e. a pair of LMF and NG-RAN node may have more than one instance of an NRPPa procedure in execution at the same time.

For possible extensibility, the protocol is considered to operate between a generic "access node" (e.g. gNB, ng-eNB) and a "server" (e.g. LMF). A procedure is only initiated by the server.



Figure 7.2.1-1: A single NRPPa transaction

Figure 7.2.1-1 shows a single NRPPa transaction. The transaction is terminated in step 2 in the case of a non UE associated procedure. For a UE associated procedure to gather information concerning the access node, additional responses may be allowed (e.g. sending of updated information periodically and/or whenever there is some significant change). In this case, the transaction may be ended after some additional responses. In the NRPPa protocol, the described transaction may be realized by the execution of one procedure defined as a request and a response, followed by one or several procedures initiated by the NG-RAN node (each procedure defined as a single message) to realize the additional responses. The Correlation ID, as specified in TS 29.572 [33], included by the LMF when it invokes the Namf\_Communication\_N1N2MessageTransfer AMF service operation to transfer the NRPPa PDU may be used by the LMF to identify the target UE positioning session.

### 7.2.2 NRPPa transaction types

#### 7.2.2.1 Location information transfer

The term "location information" applies both to an actual position estimate and to values used in computing position (e.g., radio measurements or positioning measurements). It is delivered in response to a request.



Figure 7.2.2‑1: Location information transfer

1. The server sends a request for location related information to the NG-RAN node, and indicates the type of location information needed and associated QoS. The request may refer to a particular UE.

2. In response to step 1, the NG-RAN Node transfers location related information to the server. The location related information transferred should match the location related information requested in step 1.

3. If requested in step 1, the NG-RAN node may transfer additional location related information to the server in one or more additional NRPPa messages when the positioning method is E-CID for E-UTRA.

## 7.3 Service Layer Support using combined LPP and NRPPa Procedures

### 7.3.1 General

As described in TS 23.502 [26] and TS 23.273 [35], UE-positioning-related services can be instigated from the 5GC for an NI-LR or MT‑LR location service, or from the UE in case of an MO-LR location service. The complete sequence of operations in the 5GC is defined in TS 23.502 [26] and TS 23.273 [35]. This clause defines the overall sequences of operations that occur in the LMF, NG-RAN and UE as a result of the 5GC operations.

### 7.3.2 NI-LR and MT-LR Service Support

Figure 7.3.2-1 shows the sequence of operations for an NI-LR or MT-LR location service, starting at the point where the AMF initiates the service in the LMF.



Figure 7.3.2-1: UE Positioning Operations to support an MT-LR or NI-LR

1. The AMF sends a location request to the LMF for a target UE and may include associated QoS.

2. The LMF may obtain location related information from the UE and/or from the serving NG-RAN Node. In the former case, the LMF instigates one or more LPP procedures to transfer UE positioning capabilities, provide assistance data to the UE and/or obtain location information from the UE. The UE may also instigate one or more LPP procedures after the first LPP message is received from the LMF (e.g., to request assistance data from the LMF).

3. If the LMF needs location related information for the UE from the NG-RAN, the LMF instigates one or more NRPPa procedures. Step 3 is not necessarily serialised with step 2; if the LMF and NG-RAN Node have the information to determine what procedures need to take place for the location service, step 3 could precede or overlap with step 2.

4. The LMF returns a location response to the AMF with any location estimate obtained as a result of steps 2 and 3.

### 7.3.3 MO-LR Service Support

Figure 7.3.3-1 shows the sequence of operations for an MO-LR service, starting at the point where an LCS Client in the UE or the user has requested some location service (e.g., retrieval of the UE's location or transfer of the UE's location to a third party).



Figure 7.3.3-1: UE Positioning Operations to support an MO-LR

1. The UE sends a NAS level MO-LR request to the AMF. The MO-LR request may carry an LPP PDU to instigate one or more LPP procedures to transfer capabilities, request assistance data, request location information and/or transfer location information (e.g. location measurements).

2. The AMF sends a location request to the LMF and includes any LPP PDU received in step 1.

3. The LMF may obtain location related information from the UE and/or from the serving NG-RAN node. In the former case or if an immediate response is needed to any LPP procedure instigated by the UE in step 1 (e.g., a request for assistance data), the LMF instigates one or more LPP procedures to transfer UE positioning capabilities, provide assistance data to the UE and/or obtain location information from the UE. The UE may also instigate further LPP procedures after the first LPP message is received from the LMF (e.g., to request assistance data or to request further assistance data).

4. If the LMF needs location related information for the UE from the NG-RAN, the LMF instigates one or more NRPPa procedures. Step 4 may also precede step 3 or occur in parallel with it.

5. The LMF returns a location response to the AMF with any location estimate obtained as a result of steps 3 and 4, and/or with a final LPP message (e.g., that could provide a location estimate to the UE if requested by the UE in step 1).

6. If the UE requested location transfer to a third party the AMF transfers the location received from the LMF in step 5 to the third party as defined in TS 23.273 [35].

7. The AMF sends a NAS level MO-LR response to the UE, carrying any final LPP PDU that was received in step 5.

## 7.4 General RRC procedures for UE Positioning

### 7.4.1 NR RRC Procedures

NR RRC supports the following positioning related procedures:

- Location Measurement Indication.

#### 7.4.1.1 Location Measurement Indication

The location measurement indication procedure is used by the UE to request measurement gaps for OTDOA RSTD measurements, or for subframe and slot timing detection for inter-RAT E-UTRA RSTD measurements.



Figure 7.4.1.1-1: Location measurement indication procedure

**Precondition:** The UE served by a gNB has received a LPP message from an LMF requesting inter-RAT RSTD measurements for OTDOA positioning.

1. If the UE requires measurement gaps for performing the requested location measurements while measurement gaps are either not configured or not sufficient, or if the UE needs gaps to acquire the subframe and slot timing of the target E-UTRA system before requesting measurement gaps for the inter-RAT RSTD measurements (see TS 38.133 [32], the UE sends an RRC Location Measurement Indication message to the serving gNB. The message indicates that the UE is going to start location measurements, or that the UE is going to acquire subframe and slot timing of the target E-UTRA system, and includes information required for the gNB to configure the appropriate measurement gaps. When the gNB has configured the required measurement gaps the UE performs the location measurements or timing acquisition procedures.

2. When the UE has completed the location procedures which required measurement gaps, the UE sends another RRC Location Measurement Indication message to the serving gNB. The message indicates that the UE has completed the location measurements or timing acquisition procedures.

### 7.4.2 LTE RRC Procedures

LTE RRC supports the following positioning related procedures:

- Inter-frequency RSTD measurement indication.

#### 7.4.2.1 Inter-frequency RSTD measurement indication

The Inter-frequency RSTD measurement indication procedure is used by the UE to request measurement gaps for OTDOA RSTD measurements.



Figure 7.4.2.1-1: Inter-frequency RSTD measurement indication procedure

**Precondition:** The UE served by an ng-eNB has received a LPP message from an LMF requesting inter‑frequency RSTD measurements for OTDOA positioning.

1. If the UE requires measurement gaps for performing the requested inter‑frequency RSTD measurements for OTDOA positioning while measurement gaps are either not configured or not sufficient, the UE sends an RRC Inter-frequency RSTD Measurement Indication message to the serving ng-eNB. The message indicates that the UE is going to start inter-frequency RSTD measurements and includes information required for the ng-eNB to configure the appropriate measurement gaps. When the ng-eNB has configured the required measurement gaps the UE performs the inter-frequency RSTD measurements.

2. When the UE has completed the inter-frequency RSTD measurements which required measurement gaps, the UE sends another RRC Inter-frequency RSTD Measurement Indication message to the serving ng-eNB. The message indicates that the UE has completed the inter-frequency RSTD measurements.

## 7.5 Procedures for Broadcast of Assistance Data

### 7.5.1 General

Positioning assistance data can be included in positioning System Information Blocks (posSIBs) as described in TS 36.331 [13], TS 38.331 [14] and TS 36.355 [19]. The posSIBs are carried in RRC System Information (SI) messages. The mapping of posSIBs (assistance data) to SI messages is flexibly configurable and provided to the UE in SIB1 for NG-RAN node TS 36.331 [13], TS 38.331 [14].

For each assistance data element, a separate posSIB-type is defined in TS 36.355 [19]. Each posSIB may be ciphered by the LMF using the 128-bit Advanced Encryption Standard (AES) algorithm (with counter mode) as described in TS 36.355 [19], either with the same or different ciphering key. The posSIBs which exceed the maximum size limit defined in TS 36.331 [13], TS 38.331 [14] shall be segmented by the LMF.

### 7.5.2 Broadcast Procedures

The general procedures for broadcast of positioning assistance data and delivery of ciphering keys to UEs is described in TS 23.273 [35]. This sub-clause defines the overall sequences of operations that occur in the LMF, NG-RAN node and UE.



Figure 7.5.2-1: Procedures to support broadcast of assistance data.

1. The LMF sends an NRPPa Assistance Information Control message to the NG-RAN node with an indication to start broadcasting assistance information. The message includes one or more System Information groups, where each group contains the broadcast periodicity and one or more posSIB types together with meta data to be scheduled in the same SI message. Each posSIB type may be ciphered and/or segmented at the LMF. The meta data may include an indication whether the posSIB type in the System Information group is ciphered or not, as well as an indication of an applicable GNSS type.

2. The NG-RAN node includes the received System Information groups in RRC System Information Messages and corresponding scheduling information in SIB1 as described in TS 36.331 [13], TS 38.331 [14]. The UE applies the system information acquisition procedure according to TS 36.331 [13], TS 38.331 [14] for acquiring the assistance data information that is broadcasted.

3. If the posSIB types were ciphered by the LMF, the LMF invokes the Nlmf\_Broadcast\_CipheringKeyData Notify service operation towards the AMF carrying one or more ciphering keys. 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 posSIB types. The AMF may then distribute successfully stored ciphering keys and their validity times and validity areas to suitably subscribed UEs using a mobility management message as described in TS 23.273 [35]. The LMF repeats this procedure whenever a ciphering key changes.

4. At any time after Step 1, the NG-RAN node may send a NRPPa Assistance Information Feedback message to the LMF providing feedback on assistance information broadcasting. The message may include an assistance information failure list indicating that certain posSIB types could not be configured for broadcasting by the NG-RAN node.

5. If the assistance information in a System Information group changes, the LMF provides updated information in a NRPPa Assistance Information Control message.

6. The NG-RAN node replaces the previously stored System Information groups with the new information received at Step 5 and includes the new System Information groups in RRC System Information Messages.

7. If the LMF wants to abort the broadcast of a System Information Group, it sends a NRPPa Assistance Information Control message to the NG-RAN node including an indication to stop broadcasting the assistance information.

## 8.9 NR Enhanced cell ID positioning methods

### 8.9.1 General

NR Enhanced Cell ID (NR E-CID) positioning refers to techniques which use UE and/or NR radio resource related measurements to improve the UE location estimate.

NOTE: For NR E-CID positioning methods the UE reports only the measurements that it has available rather than being required to take additional measurement actions. Therefore, the measurement gap request procedure described in clause 7.4.1.1 is not applicable for NR E-CID positioning methods.

NR E-CID measurements may include:

UE measurements (TS 38.215 [37]):

- SS Reference signal received power (SS-RSRP);

- SS Reference Signal Received Quality (SS-RSRQ);

- CSI Reference signal received power (CSI-RSRP);

- CSI Reference Signal Received Quality (CSI-RSRQ).

Various techniques exist to use these measurements to estimate the location of the UE. The specific techniques are beyond the scope of this specification.

### 8.9.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE.

#### 8.9.2.1 Information that may be transferred from the LMF to UE

UE-assisted NR Enhanced Cell-ID location does not require any assistance data to be transferred from the LMF to the UE.

UE-Based NR Enhanced Cell-ID location is not supported in this version of the specification.

#### 8.9.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in table 8.9.2.2-1.

Table 8.9.2.2-1: Information that may be transferred from UE to the LMF

|  |  |
| --- | --- |
| Information | UE‑assisted |
| SS Reference signal received power (SS-RSRP) | Yes |
| SS Reference Signal Received Quality (SS-RSRQ) | Yes |
| CSI Reference signal received power (CSI-RSRP) | Yes |
| CSI Reference Signal Received Quality (CSI-RSRQ) | Yes |
| NR Cell Global Identifier, Physical Cell ID | Yes |

### 8.9.3 NR E-CID Positioning Procedures

The procedures described in this clause support NR E-CID related measurements obtained by the UE and provided to the LMF using LPP.

#### 8.9.3.1 Capability Transfer Procedure

The Capability Transfer procedure for NR E-CID positioning is described in clause 7.1.2.1.

#### 8.9.3.2 Assistance Data Transfer Procedure

Assistance data transfer is not required for NR E-CID positioning.

#### 8.9.3.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

##### 8.9.3.3.1 LMF-initiated Location Information Transfer from UE

Figure 8.9.3.3-1 shows the Location Information Transfer operations for the NR E-CID method from UE when the procedure is initiated by the LMF.



Figure 8.9.3.3.1-1: LMF-initiated Location Information Transfer Procedure.

(1) The LMF sends a LPP Request Location Information message to the UE for invocation of NR E-CID positioning. This request includes the NR E-CID measurements requested by the LMF and supported by the UE as listed in Table 8.9.2.2-1 together with a required response time.

(2) The UE performs the requested measurements and sends an LPP Provide Location Information message to the LMF before the Response Time provided in step (1) elapsed. If the UE is unable to perform the requested measurements, or if the Response Time provided in step 1 elapsed before any of the requested measurements have been obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

##### 8.9.3.3.2 UE-initiated Location Information Delivery procedure

Figure 8.9.3.3.2-1 shows the Location Information Delivery procedure operations for the NR E-CID method when the procedure is initiated by the UE.



Figure 8.9.3.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE measurements already available at the UE.

## 8.10 Multi-RTT positioning

### 8.10.1 General

In the Multi-RTT positioning method, the UE position is estimated based on measurements performed at both, UE and TRPs. The measurements performed at the UE and TRPs are RxTx time difference measurements (and optionally DL PRS RSRP and UL SRS RSRP) of DL PRS and UL SRS, which are used by an LMF to determine the RTTs.

The UE may require measurement gaps to perform the Multi-RTT measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

### 8.10.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.10.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in table 8.10.2.1-1.

Table 8.10.2.1-1: Information that may be transferred from LMF to the UE

|  |
| --- |
| Information |
| Physical cell IDs (PCIs), global cell IDs (GCIs), and TRP IDs of candidate NR TRPs for measurement |
| Timing relative to the serving (reference) TRP of candidate NR TRPs |
| DL-PRS configuration of candidate NR TRPs |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |

#### 8.10.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.10.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.10.2.2-1: Information that may be transferred from UE to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP ID for each measurement |
| DL PRS RSRP measurement |
| UE Rx-Tx time difference measurement |
| Time stamp of the measurement |
| Quality for each measurement |

#### 8.10.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in table 8.10.2.3-1.

Table 8.10.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.10.2.3-2.

Table 8.10.2.3-2: UL information/UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |

The measurement results that may be signalled from gNBs to the LMF is listed in table 8.10.2.3-3.

Table 8.10.2.3-3: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| gNB Rx-Tx time difference measurement |
| UL SRS-RSRP |
| UL Angle of Arrival (azimuth and elevation) |
| Time stamp of the measurement |
| Quality for each measurement |

#### 8.10.2.4 Information that may be transferred from the LMF to gNBs

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in table 8.10.2.4-1.

Table 8.10.2.4-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions |
| Bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNBs is listed in table 8.10.2.4-2.

Table 8.10.2.4-2: TRP Measurement request information that may be transferred from LMF to gNBs.

|  |
| --- |
| Information |
| PCI, GCI, and TRP ID of the TRP to receive UL SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty of candidate TRPs (search window), for reception of SRS by candidate TRPs |
| Start time, duration and report characteristics for the measurements |

### 8.10.3 Multi-RTT Positioning Procedures

The procedures described in this clause support Multi-RTT positioning measurements obtained by the UE and TRPs.

#### 8.10.3.1 Procedures between LMF and UE

##### 8.10.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for Multi-RTT positioning is described in clause 7.1.2.1.

##### 8.10.3.1.2 Assistance Data Transfer Procedure

###### 8.10.3.1.2.1 Assistance Data Transfer between LMF and UE

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure).

8.10.3.1.2.1.1 LMF initiated Assistance Data Delivery

Figure 8.10.3.1.2.1.1-1 shows the Assistance Data Delivery operations for the Multi-RTT positioning method when the procedure is initiated by the LMF.



Figure 8.10.3.1.2.1.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the Multi-RTT positioning assistance data defined in Table 8.10.2.1-1.

8.10.3.1.2.1.2 UE initiated Assistance Data Transfer

Figure 8.10.3.1.2.1.2-1 shows the Assistance Data Transfer operations for the Multi-RTT positioning method when the procedure is initiated by the UE.



Figure 8.10.3.1.2.1.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain Multi-RTT positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific Multi-RTT assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

##### 8.10.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.10.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.10.3.1.3.1-1 shows the Location Information Transfer operations for the Multi-RTT positioning method when the procedure is initiated by the LMF.



Figure 8.10.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of Multi-RTT measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains Multi-RTT measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained Multi-RTT measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.10.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.10.3.1.3.2-1 shows the Location Information Delivery procedure operations for the Multi-RTT positioning method when the procedure is initiated by the UE.



Figure 8.10.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE Multi-RTT measurements already available at the UE.

#### 8.10.3.2 Procedures between LMF and gNB

##### 8.10.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.10.2.3-1 to the LMF, for subsequent delivery to the UE using the procedures of clause 8.10.3.1.2.1 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL SRS configuration information from the serving gNB of a target UE.

Figure 8.10.3.2.1-1 shows the TRP Information Exchange operation from the gNB to the LMF for the Multi-RTT positioning method.



Figure 8.10.3.2.1-1: LMF-initiated assistance data Delivery Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

Figure 8.10.3.2.1-2 shows the UL information Delivery operation from the serving gNB to the LMF.



**Figure 8.10.3.2.2.1-2: LMF-initiated UL Information Request Procedure**

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.10.2.3-2. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

##### 8.10.3.2.2 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.10.3.2.2-1 shows the messaging between the LMF and the gNB to perform this procedure.



**Figure 8.10.3.2.2-1: LMF-initiated Location Information Transfer Procedure**

(1) The LMF sends a NRPPa message to the selected gNB to request Multi-RTT measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.10.2.4-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested Multi-RTT measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained Multi-RTT measurements as defined in Table 8.10.2.3-3.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the Multi-RTT measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the Multi-RTT measurements as defined in Table 8.10.2.3-3. to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the Multi-RTT measurements as defined in Table 8.10.2.4-2. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested Multi-RTT measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing Multi-RTT measurement it sends a Measurement Abort message to the gNB.

### 8.10.4 Sequence of Procedure for Multi-RTT positioning

Figure 8.10.4-1 shows the messaging between the LMF, the gNBs and the UE to perform LMF-initiated Location Information Transfer Procedure for Multi-RTT.



Figure 8.10.4-1: Multi-RTT positioning procedure

0. The LMF may use the procedure in Figure 8.10.3.2.1-1 to obtain the TRP information required for Multi-RTT positioning.

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure described in subclause 8.10.3.1.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL information for the target device as described in Figure 8.10.3.2.2.1-2.

3. The serving gNB determines the resources available for UL SRS and configures the target device with the UL-SRS resource sets at step 3a.

4. The serving gNB provides the UL SRS configuration information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

NOTE: It is up to implementation on whether SRS configuration is provided earlier than DL PRS configuration.

5. The gNB activates the UE SRS transmission. The target device begins the UL SRS transmission according to the time domain behavior of UL SRS resource configuration.

6. The LMF provides the UL information to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in subclause 8.10.3.2.2. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. The LMF sends a LPP Provide Assistance Data message to the target device as described in subcaluse 8.10.3.1.2.1. The message includes any required assistance data for the target device to perform the necessary DL PRS measurements.

8. The LMF sends a LPP Request Location Information message to request Multi-RTT measurements.

9a: The target device performs the DL PRS measurements from all gNBs provided in the assistance data at step 7.

9b: Each gNB configured at step 6 measures the UE SRS transmissions from the target device.

10. The target device reports the DL PRS measurements for Multi-RTT to the LMF in a LPP Provide Location Information message.

11. Each gNB reports the UE SRS measurements to the LMF in a NRPPa Measurement Response message as described in subclause 8.10.3.2.2.

12. The LMF determines the RTTs from the UE and gNB Rx-Tx Time Difference Measurements for each gNB for which corresponding UL and DL measurements were provided at steps 10 and 11 and calculates the position of the target device.

## 8.11 DL AoD positioning

### 8.11.1 General

In the DL AoD positioning method, the UE position is estimated based on DL PRS RSRP measurements taken at the UE of downlink radio signals from multiple NR TRPs, along with knowledge of the spatial information of the downlink radio signals and geographical coordinates of the TRPs.

The UE while connected to a gNB may require measurement gaps to perform the DL AoD measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

The specific positioning techniques used to estimate the UE's location from this information are beyond the scope of this specification.

### 8.11.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.11.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in table 8.11.2.1-1.

Table 8.11.2.1-1: Information that may be transferred from LMF to the UE

|  |
| --- |
| Information |
| Physical cell IDs (PCIs), global cell IDs (GCIs), and TRP IDs of candidate NR TRPs for measurement |
| Timing relative to the serving (reference) TRP of candidate NR TRPs |
| DL-PRS configuration of candidate NR TRPs |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

#### 8.11.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.11.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.11.2.2-1: Information that may be transferred from UE to the LMF

|  |  |  |
| --- | --- | --- |
| Information | UE‑assisted | UE‑based |
| Latitude/Longitude/Altitude, together with uncertainty shape | No | Yes |
| PCI, GCI, and TRP ID for each measurement | Yes | No |
| DL PRS RSRP measurement | Yes | No |
| Time stamp of the measurement | Yes | No |
| Quality for each measurement | Yes | No |

#### 8.11.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in table 8.11.2.3-1.

Table 8.11.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

### 8.11.3 DL AoD Positioning Procedures

The procedures described in this clause support UE-assisted and UE-based DL AOD.

#### 8.11.3.1 Procedures between LMF and UE

##### 8.11.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for DL AoD positioning is described in clause 7.1.2.1.

##### 8.11.3.1.2 Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure).

###### 8.11.3.1.2.1 LMF initiated Assistance Data Delivery

Figure 8.11.3.1.2.1-1 shows the Assistance Data Delivery operations for the DL AoD positioning method when the procedure is initiated by the LMF.



Figure 8.11.3.1.2.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the DL AoD positioning assistance data defined in Table 8.11.2.1-1.

###### 8.11.3.1.2.2 UE initiated Assistance Data Transfer

Figure 8.11.3.1.2.2-1 shows the Assistance Data Transfer operations for the DL AoD positioning method when the procedure is initiated by the UE.



Figure 8.11.3.1.2.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain DL AoD positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific DL AoD assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

#### 8.11.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.11.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.11.3.1.3.1-1 shows the Location Information Transfer operations for the DL AoD positioning method when the procedure is initiated by the LMF.



Figure 8.11.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of DL AoD measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains DL AoD measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained DL PRS RSRP measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.11.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.11.3.1.3.2-1 shows the Location Information Delivery procedure operations for the DL-AoD positioning method when the procedure is initiated by the UE.



Figure 8.11.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE DL AoD measurements already available at the UE.

#### 8.11.3.2 Procedures between LMF and gNB

##### 8.11.3.2.1 Assistance Data Delivery procedure

The purpose of this procedure is to enable the gNB to provide assistance data described in Table 8.11.2.3-1 to the LMF, for subsequent delivery to the UE using the procedures of clause 8.11.3.1.2 or for use in the calculation of positioning estimates at the LMF.

###### 8.11.3.2.1.1 LMF-initiated assistance data delivery to the LMF

Figure 8.11.3.2.1.1-1 shows the TRP Information Exchangeoperation from the gNB to the LMF for the DL AoD positioning method.



Figure 8.11.3.2.1.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP informationin an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

## 8.12 DL TDOA positioning

### 8.12.1 General

In the DL TDOA positioning method, the UE position is estimated based on DL RSTD (and optionally DL PRS RSRP) measurements taken at the UE of downlink radio signals from multiple NR TRPs, along with knowledge of the geographical coordinates of the TRPs and their relative downlink timing.

The UE while connected to a gNB may require measurement gaps to perform the DL TDOA measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

The specific positioning techniques used to estimate the UE's location from this information are beyond the scope of this specification.

### 8.12.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.12.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in table 8.12.2.1-1.

Table 8.12.2.1-1: Information that may be transferred from LMF to the UE

|  |
| --- |
| Information |
| Physical cell IDs (PCIs), global cell IDs (GCIs), and TRP IDs of candidate NR TRPs for measurement |
| Timing relative to the serving (reference) TRP of candidate NR TRPs |
| DL-PRS configuration of candidate NR TRPs |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

#### 8.12.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.12.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.12.2.2-1: Information that may be transferred from UE to the LMF

|  |  |  |
| --- | --- | --- |
| Information | UE‑assisted | UE‑based |
| Latitude/Longitude/Altitude, together with uncertainty shape | No | Yes |
| PCI, GCI, and TRP ID for each measurement | Yes | No |
| DL RSTD measurement | Yes | No |
| DL PRS RSRP measurement | Yes | No |
| Time stamp of the measurement | Yes | No |
| Quality for each measurement | Yes | No |

#### 8.12.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in Table 8.12.2.3-1.

Table 8.12.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) |

### 8.12.3 DL TDOA Positioning Procedures

The procedures described in this clause support UE-assisted and UE-based DL TDOA.

#### 8.12.3.1 Procedures between LMF and UE

##### 8.12.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for DL TDOA positioning is described in clause 7.1.2.1.

##### 8.12.3.1.2 Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure).

###### 8.12.3.1.2.1 LMF initiated Assistance Data Delivery

Figure 8.12.3.1.2.1-1 shows the Assistance Data Delivery operations for the DL TDOA positioning method when the procedure is initiated by the LMF.



Figure 8.12.3.1.2.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the DL TDOA positioning assistance data defined in Table 8.12.2.1-1.

###### 8.12.3.1.2.2 UE initiated Assistance Data Transfer

Figure 8.12.3.1.2.2-1 shows the Assistance Data Transfer operations for the DL TDOA positioning method when the procedure is initiated by the UE.



Figure 8.12.3.1.2.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain DL TDOA positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific DL TDOA assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

##### 8.12.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.12.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.12.3.1.3.1-1 shows the Location Information Transfer operations for the DL TDOA positioning method when the procedure is initiated by the LMF.



Figure 8.12.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of DL TDOA measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains DL TDOA measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained DL RSTD measurements and, optionally, the DL PRS RSRP measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.12.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.12.3.1.3.2-1 shows the Location Information Delivery procedure operations for the DL-TDOA positioning method when the procedure is initiated by the UE.



Figure 8.12.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE DL TDOA measurements and, optionally, the DL PRS RSRP measurements already available at the UE.

#### 8.12.3.2 Procedures between LMF and gNB

##### 8.12.3.2.1 Assistance Data Delivery procedure

The purpose of this procedure is to enable the gNB to provide assistance data to the LMF, for subsequent delivery to the UE using the procedures of clause 8.12.3.1.2 or for use in the calculation of positioning estimates at the LMF.

###### 8.12.3.2.1.1 LMF-initiated assistance data delivery to the LMF

Figure 8.12.3.2.1.1-1 shows the TRP Information Exchange operation from the gNB to the LMF for the DL TDOA positioning method.



Figure 8.12.3.2.1.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

## 8.13 UL TDOA positioning

### 8.13.1 General

In the UL TDOA positioning method, the UE position is estimated based on UL RTOA (and optionally UL SRS RSRP) measurements taken at different TRPs of uplink radio signals from UE, along with other configuration information.

The specifics of any UL TDOA positioning methods or techniques used to estimate the UE's location from these measurements are beyond the scope of this specification.

In order to obtain uplink measurements, the TRPs need to know the characteristics of the SRS signal transmitted by the UE for the time period required to perform uplink measurement. These characteristics should be static over the periodic transmission of SRS during the uplink measurements. Hence, the LMF will indicate to the serving gNB the need to direct the UE to transmit SRS signals for uplink positioning. It is up to the serving gNB to make the final decision on resources to be assigned and to communicate this SRS configuration information back to the LMF so that LMF can forward the SRS configuration to the TRPs. The gNB may decide (e.g., in case no resources are available) to configure no resources for the UE and report the empty resource configuration to the LMF.

### 8.13.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and gNB/TRPs.

#### 8.13.2.0 Assistance Data that may be transferred from the gNB to the LMF

The assistance data that may be transferred from the gNB to the LMF is listed in Table 8.13.2.0-1.

Table 8.13.2.0-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Geographical coordinates of the TRPs served by the gNB (include reference location for the receiving antenna of the reference TRP, relative locations for receiving antennas of other TRPs) |

#### 8.13.2.1 Configuration Data that may be transferred from the gNB to the LMF

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.13.2.1-1.

Table 8.13.2.1-1: UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |

#### 8.13.2.2 Location Information that may be transferred from the gNBs to LMF

The information that may be transferred from gNBs to the LMF include measurement results listed in Table 8.13.2.2-1. The individual measurements are defined in TS 38.215 [37].

Table 8.13.2.2-1: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| UL RTOA |
| UL SRS-RSRP |
| Time stamp of the measurement |
| Quality for each measurement |

#### 8.13.2.3 Information that may be transferred from the LMF to gNBs

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in table 8.13.2.3-1.

Table 8.13.2.3-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions |
| Bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNB is listed in table 8.13.2.3-2.

Table 8.13.2.3-2: TRP Measurement request information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| PCI, GCI, and TRP ID of the TRP to receiveUL SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty of candidate TRPs (search window), for reception of SRS by candidate TRPs |
| Start time, duration and report characteristics for the measurements |

### 8.13.3 UL TDOA Positioning Procedures

The procedures described in this clause support UL TDOA positioning measurements obtained by the gNB and provided to the LMF using NRPPa.

#### 8.13.3.1 Capability Transfer Procedure

The Capability Transfer procedure for UL-TDOA positioning is described in clause 7.1.2.1.

#### 8.13.3.2 Assistance Data Transfer Procedure

##### 8.13.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.13.2.0-1 to the LMF, for subsequent delivery to the gNB using the procedures of clause 8.13.3.3 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL SRS configuration information from the serving gNB of a target UE.

Figure 8.13.3.2.1-1 shows the UL information Delivery operation from the serving gNB to the LMF.



Figure 8.13.3.2.1-1: LMF-initiated UL Information Request Procedure

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.13.2.1-1. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

Figure 8.13.3.2.1-2 shows the TRP Information Exchange operation from the gNB to the LMF for the UL TDOA positioning method.



8.13.3.2.1-2: LMF-initiated assistance data Delivery Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

#### 8.13.3.3 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.13.3.3-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.13.3.3-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a NRPPa message to the selected gNB to request UL-TDOA measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.13.2.3-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested UL-TDOA measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained UL-TDOA measurements as defined Table 8.13.2.2-1.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the UL-TDOA measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the UL-TDOA measurements as defined in Table 8.13.2.2-1 to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the UL-TDOA measurements as defined in Table 8.13.2.3-2. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested UL-TDOA measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing UL-TDOA measurement it sends a Measurement Abort message to the gNB.

#### 8.13.3.4 Sequence of Procedure for UL-TDOA positioning

Figure 8.13.3.4-1 shows the messaging between the LMF, the gNBs and the UE to perform UL-TDOA procedure.



Figure 8.13.3.4-1: UL TDOA positioning procedure

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure as described in subclause 8.13.3.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL SRS configuration information for the target device as described in subclause 8.13.3.2.1.

3. The serving gNB determines the resources available for UL SRS and configures the target device with the UL-SRS resource sets at step 3a.

4. The serving gNB provides the UL information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

5. The gNB activates the UL SRS transmission. The target device begins the UL SRS transmission according to the time domain behavior of UL SRS resource configuration.

6. The LMF provides the UL SRS configuration to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in subclause 8.13.3.3. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. Each gNB configured at step 6 measures the UL SRS transmissions from the target device.

8. Each gNB reports the UL SRS measurements to the LMF in a NRPPa Measurement Response message as described in subclause 8.13.3.3.

## 8.14 UL AoA positioning

### 8.14.1 General

In the UL AoA positioning method, the UE position is estimated based on UL AoA (and optionally UL SRS RSRP) of uplink radio signals taken at different TRPs, along with other configuration information.

The specific of any UL AoA positioning methods or techniques used to estimate the UE's location from these measurements are beyond the scope of this specification.

In order to obtain uplink measurements, the TRPs need to know the characteristics of the SRS signal transmitted by the UE for the time period required to calculate uplink measurement. These characteristics should be static over the periodic transmission of SRS during the uplink measurements. Hence, the LMF will indicate to the serving gNB the need to direct the UE to transmit SRS signals for uplink positioning. It is up to the gNB to make the final decision on resources to be assigned and to communicate this configuration information back to the LMF so that LMF can configure the TRPs. The gNB may decide (e.g., in case no resources are available) to configure no resources for the UE and fail the corresponding NRPPa procedure.

### 8.14.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and gNB/TRPs.

#### 8.14.2.0 Assistance Data that may be transferred from the gNB to the LMF

The assistance data that may be transferred from the gNB to the LMF is listed in Table 8.14.2.0-1.

Table 8.14.2.0-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Geographical coordinates of the TRPs served by the gNB (include reference location for the receiving antenna of the reference TRP, relative locations for receiving antennas of other TRPs) |

#### 8.14.2.1 Configuration Data that may be transferred from the gNB to the LMF

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.14.2.1-1.

Table 8.14.2.1-1: UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |

#### 8.14.2.2 Location Information that may be transferred from the gNBs to LMF

The information that may be transferred from gNBs to the LMF include measurement results are listed in Table 8.14.2.2-1. The individual measurements are defined in TS 38.215 [37].

Table 8.14.2.2-1: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| PCI, GCI, and TRP ID of the measurement |
| UL Angle of Arrival (azimuth and elevation) |
| UL SRS-RSRP |
| Time stamp of the measurement |
| Quality for each measurement |

#### 8.14.2.3 Information that may be transferred from the LMF to gNB

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in table 8.14.2.3-1.

Table 8.14.2.3-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions |
| Bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNB is listed in table 8.14.2.3-2.

Table 8.14.2.3-2: TRP Measurement request information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| PCI, GCI, and TRP ID of the TRP to receiveUL SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty of candidate TRPs (search window), for reception of SRS by candidate TRPs |
| Start time, duration and report characteristics for the measurements |

### 8.14.3 UL AoA Positioning Procedures

The procedures described in this clause support UL AoA positioning measurements obtained by the gNB and provided to the LMF using NRPPa.

#### 8.14.3.1 Capability Transfer Procedure

The Capability Transfer procedure for UL-AOA positioning is described in clause 7.1.2.1.

#### 8.14.3.2 Assistance Data Transfer Procedure

##### 8.14.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.14.2.0-1 to the LMF, for subsequent delivery to the gNB using the procedures of clause 8.14.3.3 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL SRS configuration information from the serving gNB of a target UE.

Figure 8.14.3.2.1-1 shows the UL information Delivery operation from the serving gNB to the LMF.



Figure 8.14.3.2.2.1-1: LMF-initiated UL Information Request Procedure

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.14.2.1-1. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

Figure 8.14.3.2.2.1-2 shows the TRP Information Exchange operation from the gNB to the LMF for the UL AoA positioning method.



8.14.3.2.2.1-2: LMF-initiated assistance data Delivery Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

#### 8.14.3.3 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.14.3.3-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.14.3.3-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a NRPPa message to the selected gNB to request UL-AOA measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.14.2.3-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested UL-AOA measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained UL-AOA measurements as defined in Table 8.14.2.2-1.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the UL-AOA measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the UL-AOA measurements as defined in Table 8.14.2.2-1 to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the UL-AOA measurements as defined in the clause 8.14.2.3. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested UL-AOA measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing UL-AOA measurement it sends a Measurement Abort message to the gNB.

#### 8.14.3.4 Sequence of Procedure for UL-AOA positioning

Figure 8.14.3.4-1 shows the messaging between the LMF, the gNBs and the UE to perform UL-AOA procedure.



Figure 8.14.3.4-1: UL AOA positioning procedure

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure as described in subclause 8.14.3.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL SRS configuration information for the target device as described in subclause 8.14.3.2.1.

3. The serving gNB determines the resources available for UL SRS and configures the target device with the UL-SRS resource sets at step 3a.

4. The serving gNB provides the UL SRS configuration information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

5. The gNB activates the UL SRS transmission. The target device begins the UL SRS transmission according to the time domain behavior of UL SRS resource configuration.

6. The LMF provides the UL SRS configuration to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in subclause 8.14.3.3. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. Each gNB configured at step 6 measures the UL SRS transmissions from the target device.

8. Each gNB reports the UL SRS measurements to the LMF in a NRPPa Measurement Response message as described in subclause 8.14.3.3.