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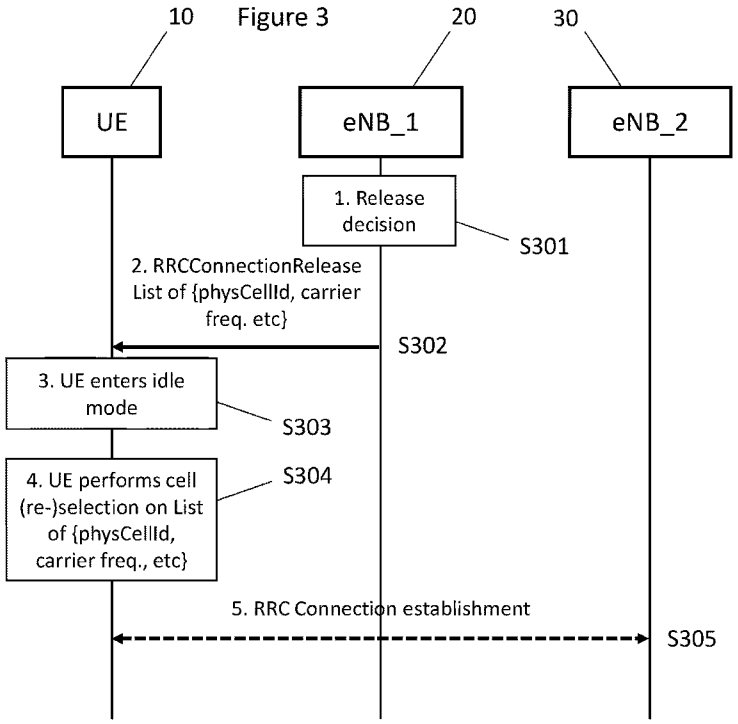
WO 2024/030818 A1 **WO 2019/137949 A1**
CN 115499886 A

(58) Field of Search:
INT CL **H04B, H04W**
Other: **SEARCH-PATENT, XP3GPP**

(54) Title of the Invention: **Device mobility in network**
Abstract Title: **Connection release with information for performing subsequent connection procedure**

(57) A method for a User Equipment (UE) (e.g. IoT) in a network (e.g. NTN) comprising the UE and two or more base stations (NBs), the method comprising: receiving, from a first NB, a connection release message (e.g. radio resource control (RRC) release message) instructing the UE to release a connection with the first NB, wherein the connection release message includes information related to one or more other NBs, the information for performing a connection procedure; releasing the connection with the first NB in response to the connection release message; entering an idle mode (e.g. RRC-idle); and performing the connection procedure to establish a connection with a second NB based on the information (e.g. RRC re-establishment). The information may comprise for a cell associated with the or more other NBs: a cell identifier, a carrier frequency, a carrier bandwidth, or a cell priority. A method for a UE comprising: receiving, from a first NB, a connection release message instructing the UE to release a connection with the first NB; determining time information; and releasing the connection with the first NB in response to the connection release message, wherein the connection is released at a time based on the time information.

Figure 3



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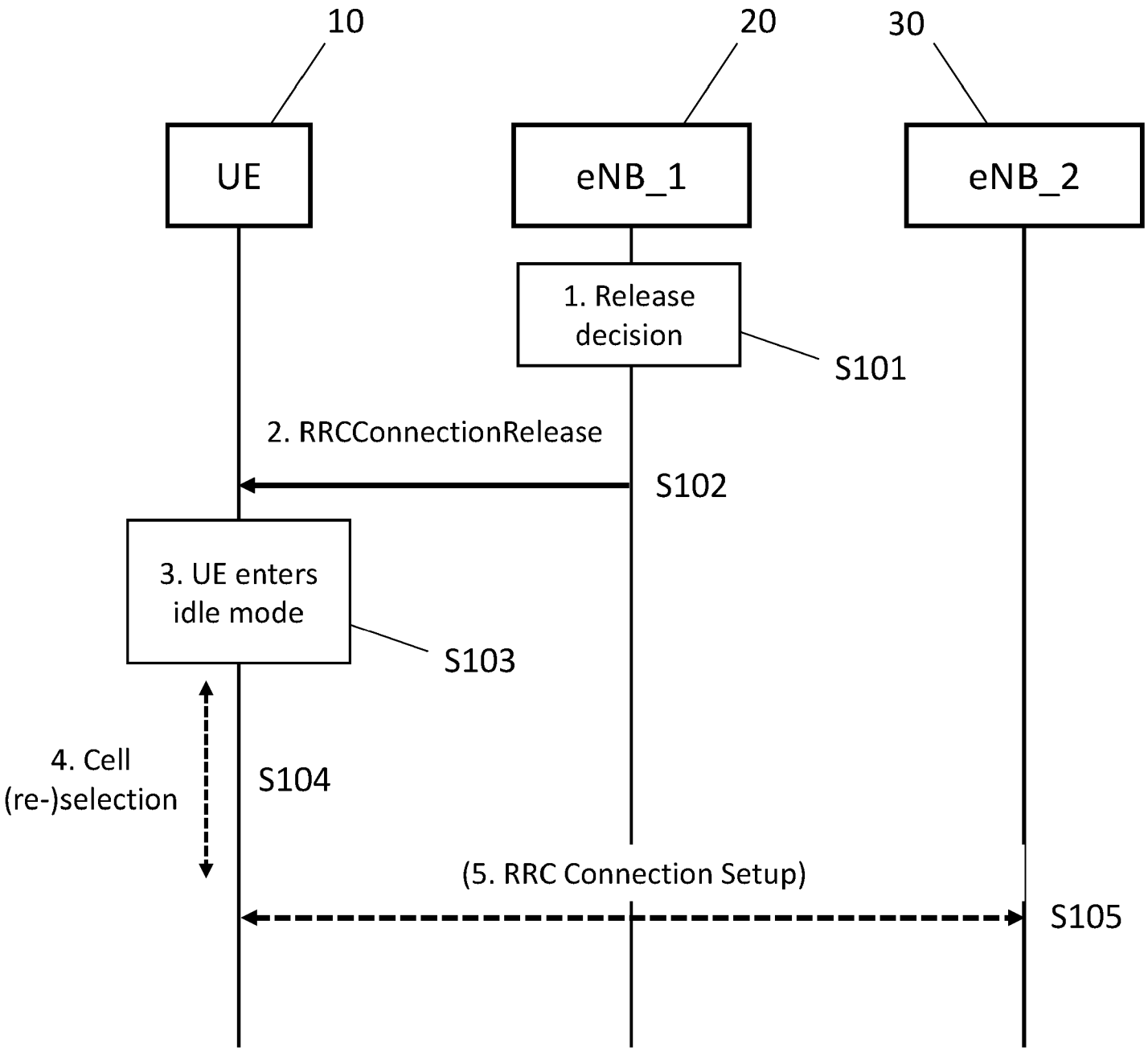
10
20
30
UE
eNB_1
eNB_2
1. Release decision
S101
2. RRCConnectionRelease
S102
3. UE enters idle mode
S103
4. Cell (re-)selection
S104
(5. RRC Connection Setup)
S105

Figure 1

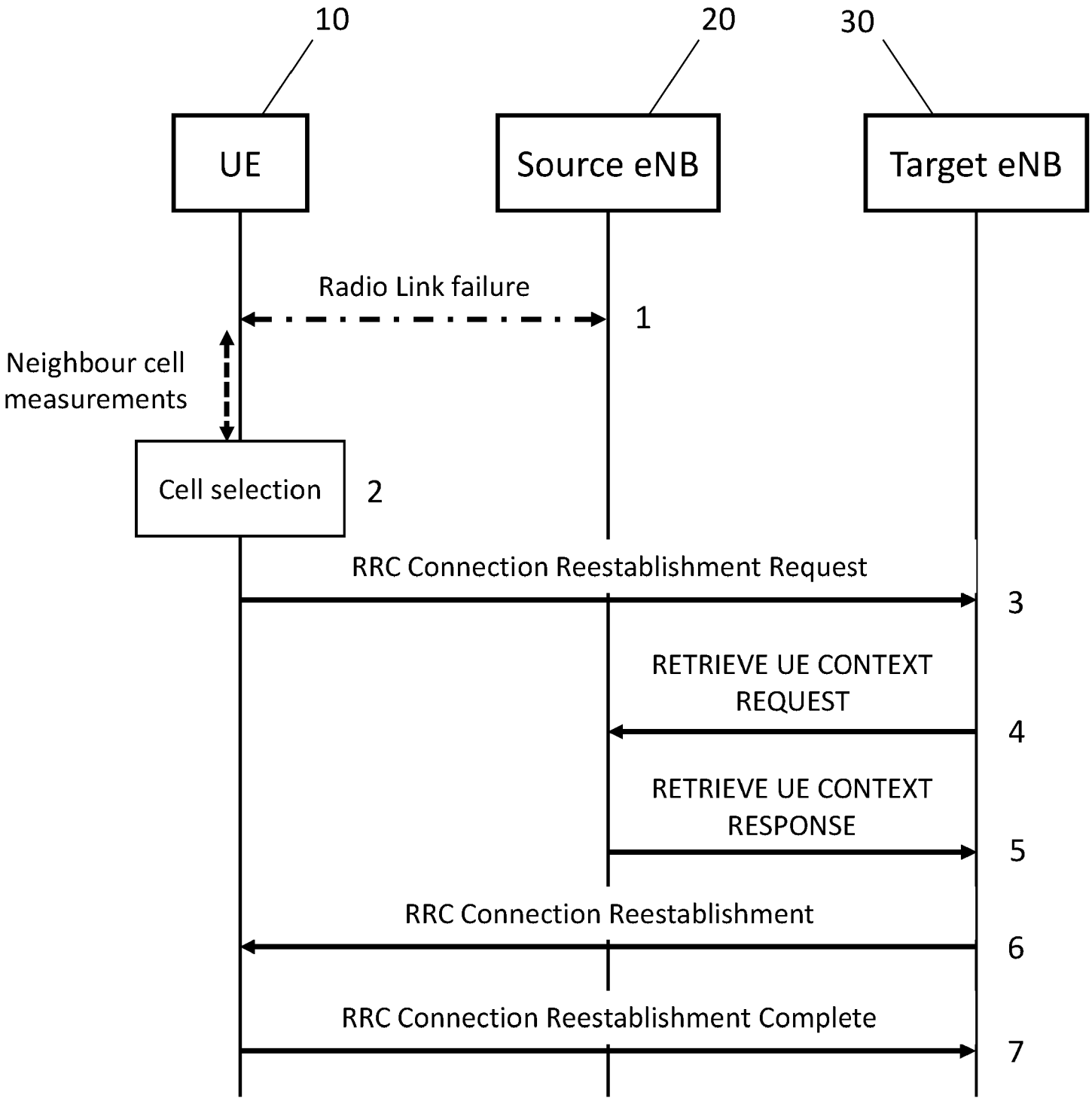
10
20
30
UE
Source eNB
Target eNB
Radio Link failure
1
Neighbour cell measurements
Cell selection
2
RRC Connection Reestablishment Request
3
RETRIEVE UE CONTEXT REQUEST
4
RETRIEVE UE CONTEXT RESPONSE
5
RRC Connection Reestablishment
6
RRC Connection Reestablishment Complete
7

Figure 2

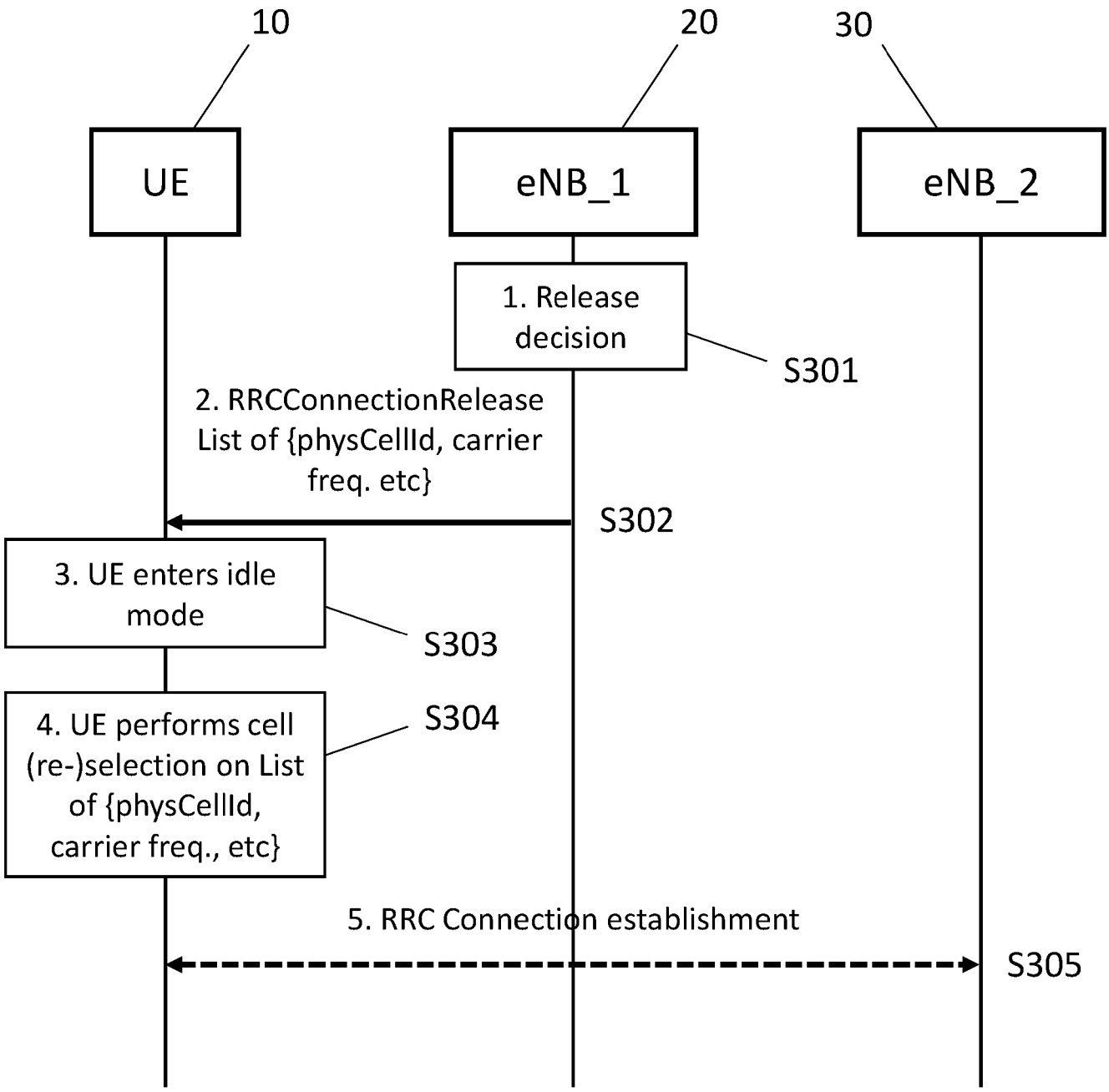
10
20
30
UE
eNB_1
eNB_2
1. Release decision
S301
2. RRCConnectionRelease List of {physCellId, carrier freq. etc}
S302
3. UE enters idle mode
S303
4. UE performs cell (re-)selection on List of {physCellId, carrier freq., etc}
S304
5. RRC Connection establishment
S305

Figure 3

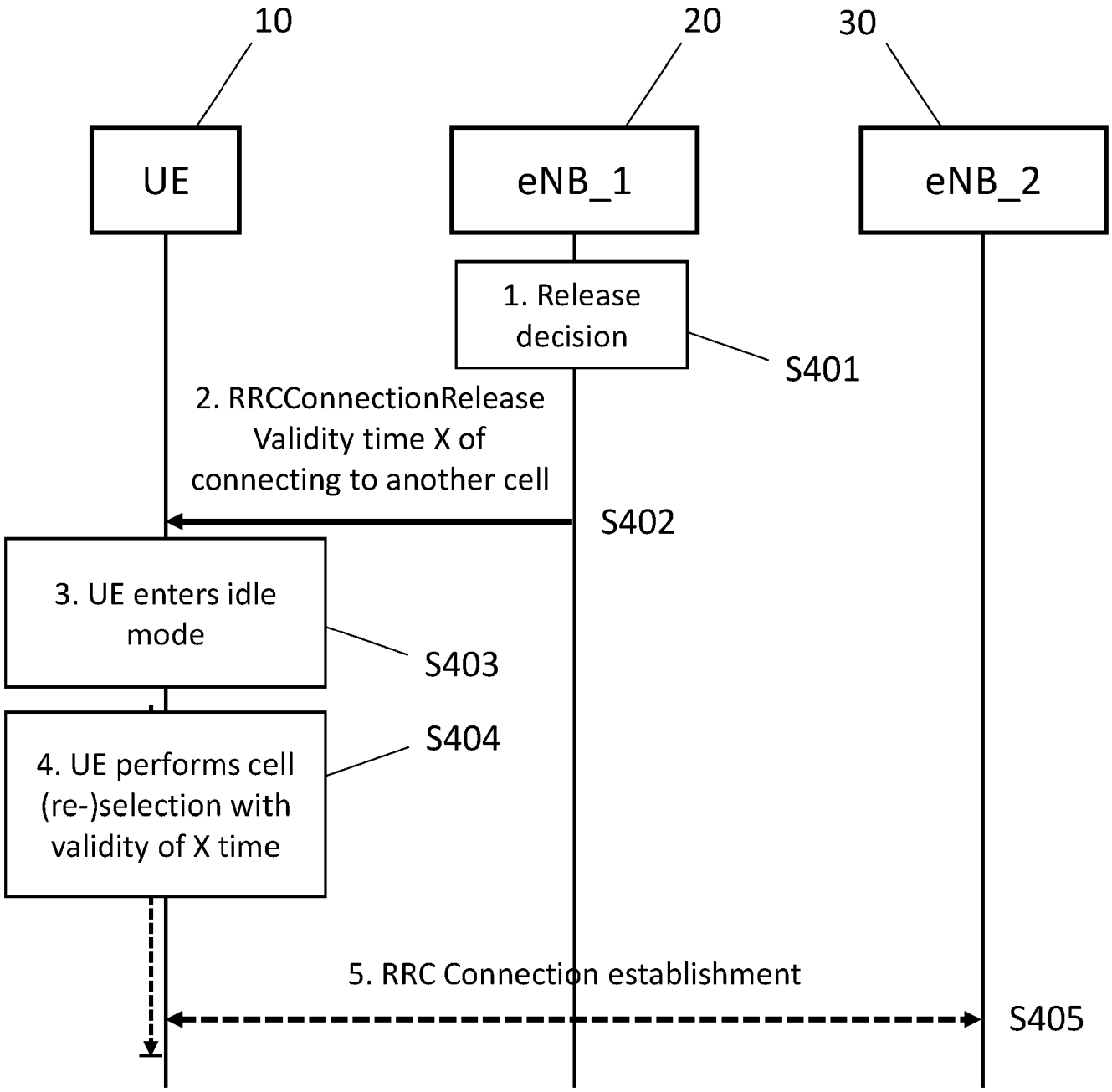
10
20
30
UE
eNB_1
eNB_2
1. Release decision
S401
2. RRCConnectionRelease
Validity time X of connecting to another cell
S402
3. UE enters idle mode
S403
4. UE performs cell (re-)selection with validity of X time
S404
5. RRC Connection establishment
S405

Figure 4

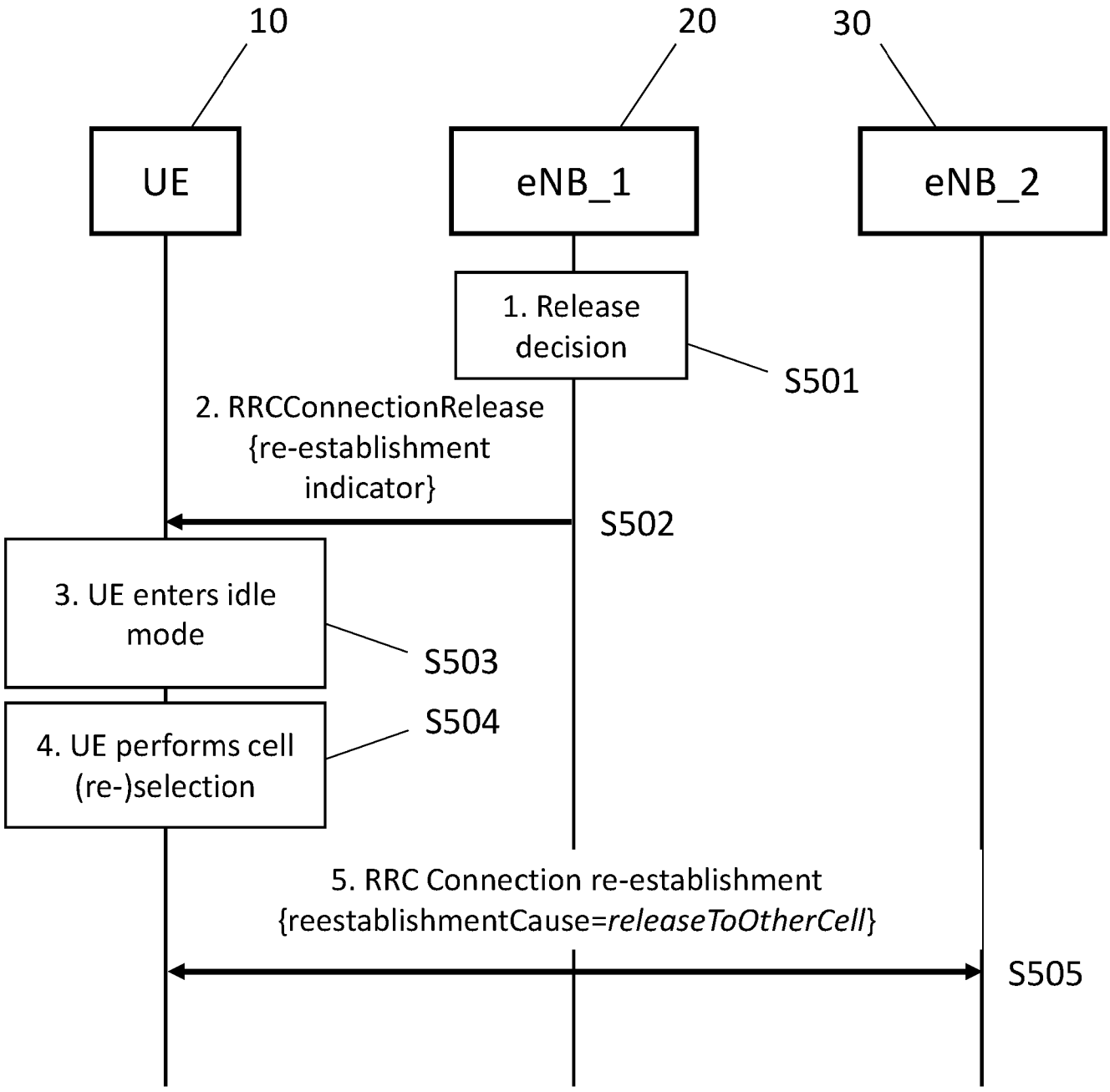
10
20
30
UE
eNB_1
eNB_2
1. Release decision
S501
2. RRCConnectionRelease {re-establishment indicator}
S502
3. UE enters idle mode
S503
4. UE performs cell (re-)selection
S504
5. RRC Connection re-establishment {reestablishmentCause=releaseToOtherCell}
S505

Figure 5

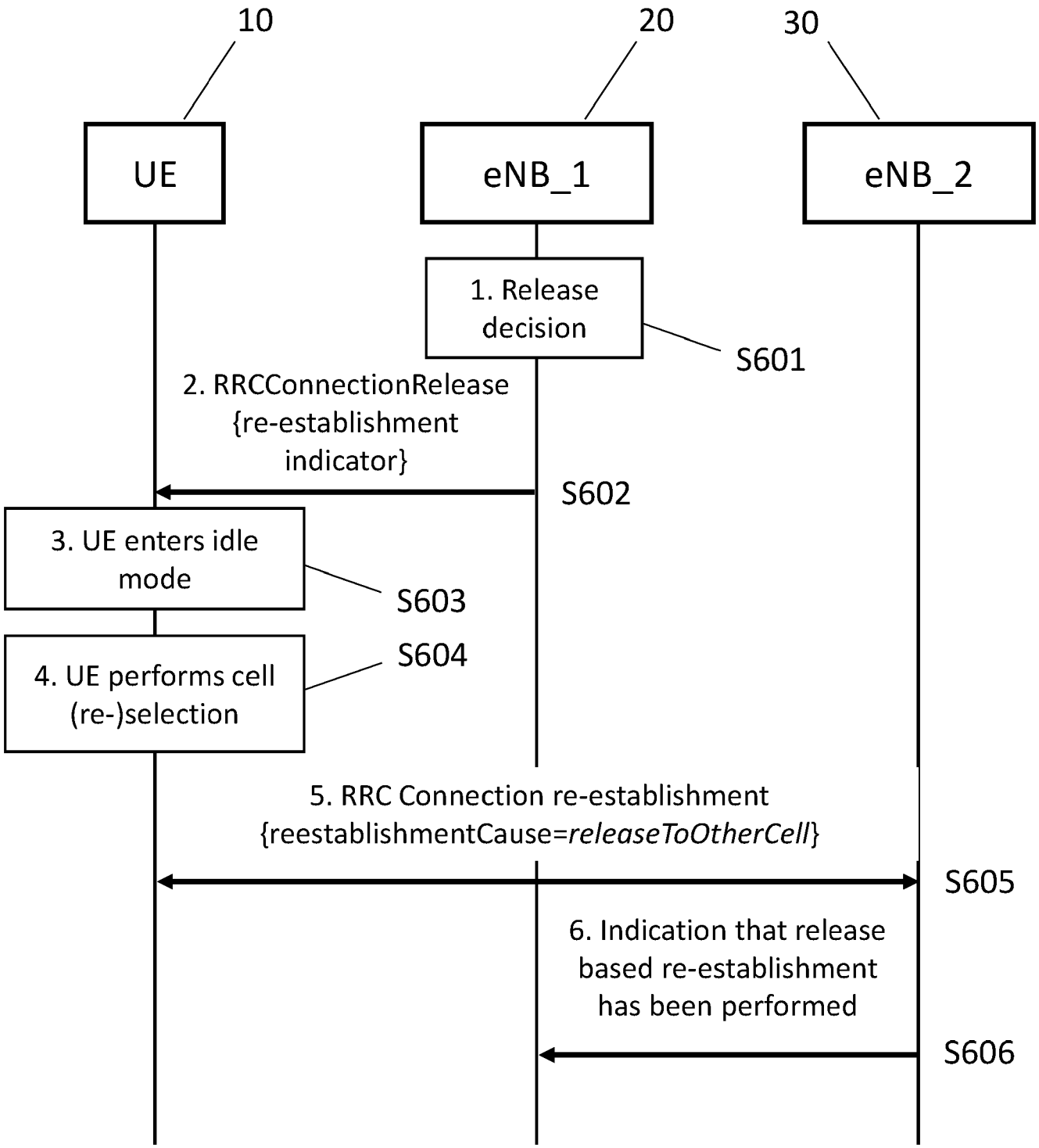
10
20
30
UE
eNB_1
eNB_2
1. Release decision
S601
2. RRCConnectionRelease {re-establishment indicator}
S602
3. UE enters idle mode
S603
4. UE performs cell (re-)selection
S604
5. RRC Connection re-establishment {reestablishmentCause=releaseToOtherCell}
S605
6. Indication that release based re-establishment has been performed
S606

Figure 6

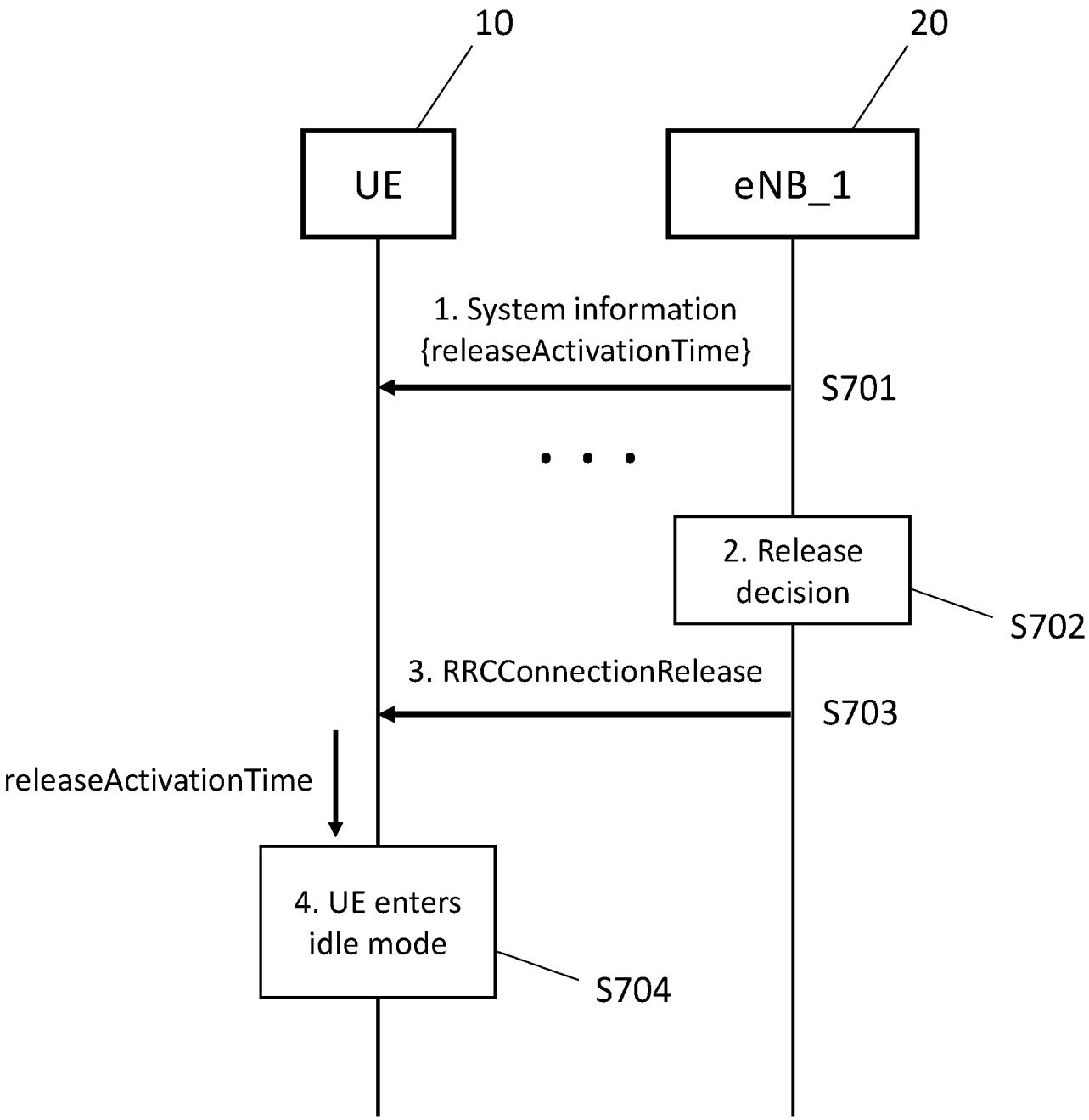
10
20
UE
eNB_1
1. System information
{releaseActivationTime}
S701
2. Release
decision
S702
3. RRCConnectionRelease
S703
releaseActivationTime
4. UE enters
idle mode
S704

Figure 7

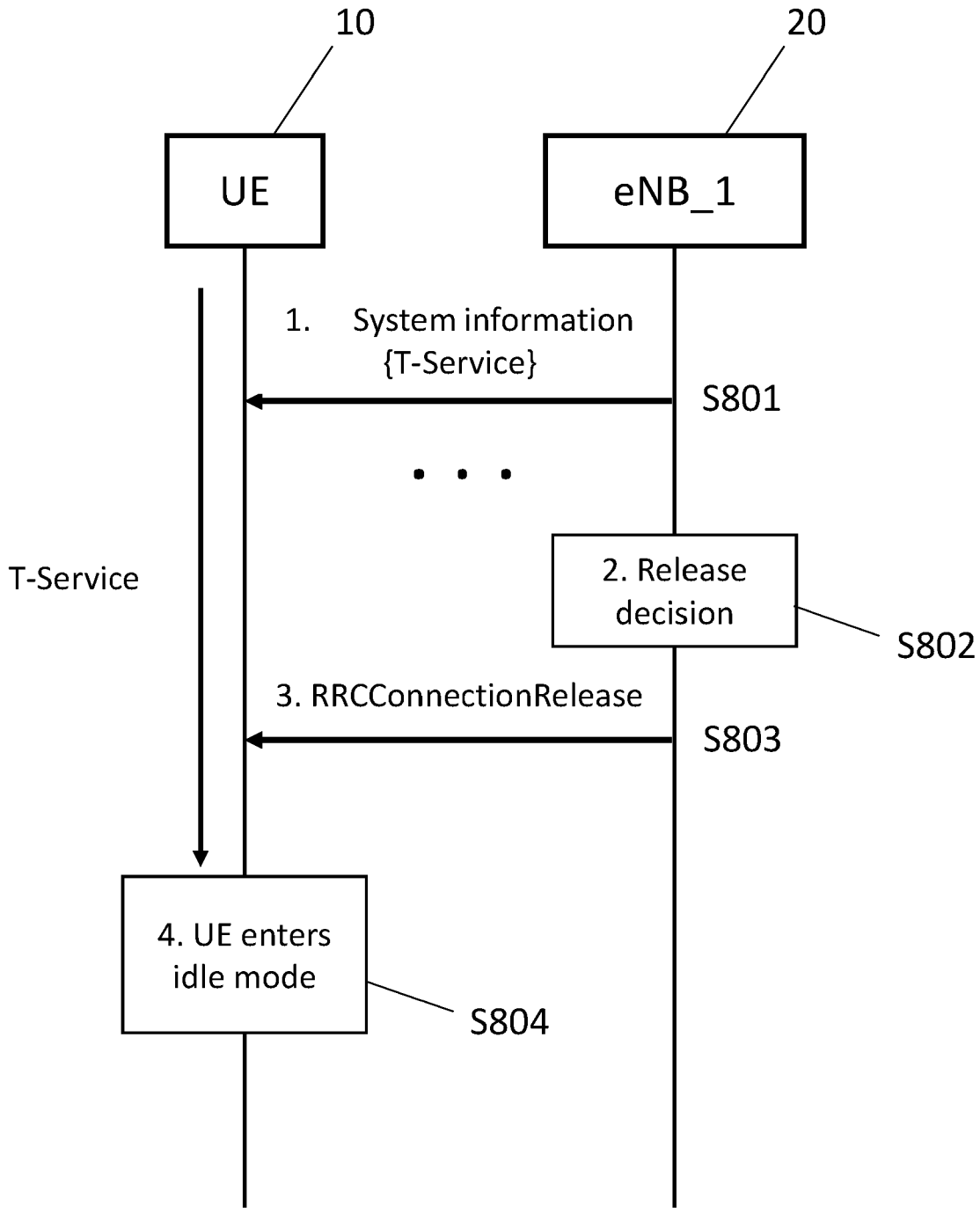
10
20
UE
eNB_1
1. System information
{T-Service}
S801
T-Service
2. Release
decision
S802
3. RRCConnectionRelease
S803
4. UE enters
idle mode
S804

Figure 8

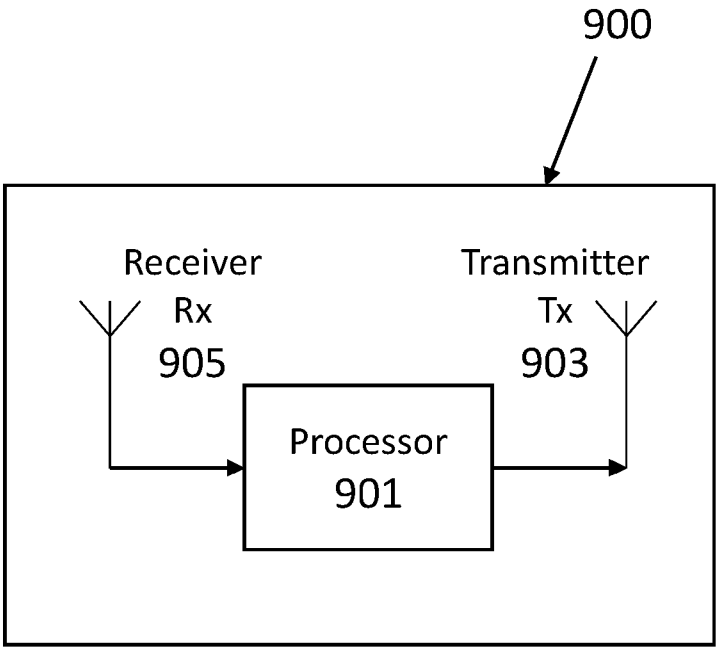

Figure 9

Device Mobility in Network

BACKGROUND

Field

Certain examples of the present disclosure provide one or more techniques for device mobility in a network. For example, certain examples of the present disclosure provide one or more techniques for Internet of Things (IoT) device mobility in a 3rd Generation Partnership Project (3GPP) 5th Generation (5G) New Radio (NR) Non Terrestrial Network (NTN) through connection release and connection establishment or re-establishment.

Description of the Related Art

Overview of NTN

One of the areas currently under development in 3GPP 5G wireless technology is support for NTNs. An NTN is a network in which one or more nodes (e.g. a Next Generation (NG) Radio Access Network (RAN) node) are provided by a non-terrestrial infrastructure, for example a satellite or High Altitude Platform Station (HAPS). Advantages of using an NTN include (i) extending coverage to regions, such as remote areas, with limited or no coverage from more traditional terrestrial networks, (ii) providing continuous coverage in the event of inoperability of traditional terrestrial networks, such as during natural disasters, and (iii) enhancing overall reliability, resilience and capacity when used in conjunction with existing terrestrial networks.

A satellite network implementing a network node provides coverage through one or more radio beams forming a "footprint" on the surface of the Earth defining a coverage area or cell. An NTN cell may be Earth-moving (i.e. moving over the Earth's surface according to the motion of the satellite, for example in the case of a Lower Earth Orbit (LEO) satellite), Earth-fixed (i.e. a fixed area of the Earth's surface, for example in the case of a Geosynchronous Equatorial Orbit (GEO) satellite) or quasi-Earth-fixed (i.e. a fixed area of the Earth's surface but is maintained for only a limited time as the satellite passes by).

Overview of IoT NTN and NR NTN

IoT NTN was a 3GPP study and work item in 3GPP Release 17 (RP-202689, RAN#90 December 2020) to provide NTN access for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) IoT devices (e.g. Narrowband (NB)-IoT and Long Term Evolution Machine Type Communication (LTE-M), including enhanced Machine Type Communication (eMTC)). As noted in 3GPP RP-202689, IoT operation is critical in remote areas with low/no cellular connectivity for many different industries. The capabilities of NB-IoT and eMTC are a good fit for many applications but some applications may require satellite connectivity to provide coverage beyond terrestrial deployments.

NR NTN was a work item in Release 17 to specify adaptation to allow NR to function over NTN (RP-211557, RAN#91-e March 2021).

Following the work items in Release 17 there were work items to enhance NR NTN (RP-220953, RAN#95-e March 2022) and IoT NTN (RP-220979, RAN#95-e March 2022) in Release 18.

Overview of Mobility

In Long Term Evolution (LTE), mobility mainly functions through handover, using RRCReconfiguration and mobilityControlInfo. Handover allows a User Equipment (UE) to maintain service continuity, and during handover the UE remains in RRC connected mode.

In NB-IoT, to support a more simplified implementation compared to LTE, mobility functions are not specified or severely simplified. As an example, for NB-IoT Release 13 (the first release of NB-IoT), there is no RRC connected mode mobility, meaning that there are no handover commands defined and no connected mode neighbour cell measurements defined. Instead, mobility in RRC connected mode is done when the connection to the serving cell deteriorates forcing the UE to perform Radio Link Failure (RLF) and then re-establish to a more suitable cell through the RRC re-establishment procedure.

A simplified mobility implementation for NB-IoT may be practical in a Terrestrial Network (TN) since major use cases of NB-IoT typically involve stationary UEs. However, in NTNs, due to the movement of satellites in a non-stationary orbit (e.g. LEO), the cells that a UE sees will be moving (i.e. Earth-moving cells). This results in frequent UE handover from one cell to another, and this handover of service will happen constantly, even in the case of stationary UEs. In view of this, mobility is one of the key issues in both NR NTN and IoT NTN.

During the study item on IoT NTN Release 17, different methods of supporting enhanced mobility with the special circumstances of NTN were discussed, in particular the problem of mobility for NB-IoT.

Overview of RRC Connection Suspend Procedures

One development in both LTE-M and NB-IoT is the introduction of a suspended RRC connection state (mode). In this state, the UE and the network maintain the RRC context. In other words, the UE stores the RRC configuration of the last serving cell to which the UE was connected, and the network maintains the UE context. This allows for much faster establishment as the UE does not need to be reconfigured every time it enters RRC connected state, and does not need to reactivate Access Stratum (AS) security, for example.

Overview of RRC Connection Release

RRC Connection Release is a procedure used to transition the UE to RRC idle mode or RRC idle mode with suspend connection. Figure 1 illustrates an exemplary scenario involving an RRC Connection Release procedure.

Referring to Figure 1, in a first operation S101, a first eNB (eNB_1) 20 decides to release a connection with a UE 10.

In a second operation S102, the first eNB 20 transmits a first message (RRCConnectionRelease message) to the UE 10 in response to the release decision.

In a third operation, S103, the UE 10 enters idle mode in response to receiving the first message.

In a fourth operation, S104, the UE 10 performs cell selection or cell re-selection.

In a fifth operation S105, the UE 10 establishes a connection with the selected cell/eNB. In the example of Figure 1, the UE 10 has selected a second eNB (eNB_2) 30, which is different from the first eNB (eNB_1) 20. The connection establishment may include transmission of one or messages between the UE 10 and the selected eNB.

In RRCConnectionRelease (E-UTRAN/LTE version) the following can be signalled:

- Release cause
  - *loadbalancingTAUrequired*
  - *other*
  - *cs-FallbackHighPriority*
  - *rrc-Suspend*
- RedirectedCarrierInfo
  - This contains frequencies of different Radio Access Technologies (RATs), such as Evolved Universal Terrestrial Radio Access (E-UTRA), GSM EDGE Radio Access Network (GERAN), Universal Terrestrial Radio Access (UTRA), cdma2000, and NR.
- idleModeMobilityControlInfo
  - This is a frequency priority list that signals different carrier frequencies and their cell reselection priority for different RATs.
  - T320, which indicates the time the frequency priority list is active.
- cellInfoList

- This provides redirection information for one or more cells on inter-RAT frequencies, including cell identities (IDs), carrier frequencies, and system information for cells on other RATs.

- MeasIdleConfig
  - This conveys information about measurements to be performed in idle mode, which is used for performing faster Carrier Aggregation (CA) establishment.
- Alternative frequency priorities
  - This signals to the UE to apply alternative cell reselection priorities.
- Release idle mode measurement config
  - This indicates that the UE shall release the idle/inactive measurement configuration, if it has been configured, and is used for early CA setup (CA/Dual Connectivity (DC) enhancements).

RRC Connection Release(-NB) contains the following:

- Release Cause
  - loadBalancingTAUrequired – this triggers TAU or other NAS procedure.
  - rrc-Suspend – this indicates to the UE to suspend its RRC connection.
  - other.
- ResumeIdentity – this is the UE identity to facilitate UE context retrieval at the eNB when resuming the connection. It is a 40-bit identity string.
- Extended wait time – this is forwarded to the upper layer of UEs with delay tolerant access. NB-IoT is by default a delay tolerant access.
- Redirected carrier info – this indicates a carrier frequency that is used to redirect the UE to a NB-IoT carrier frequency through cell reselection. In Release 14, the information may also include an offset to specific frequencies to prioritize certain frequencies, and the timer T322 determines for how long this offset is active.
- Drb continue Robust Header Compression (ROHC) – this indicates whether to continue or reset the header compression protocol context for Data Radio Bearer (DRB) configured with header compression protocol. When UE initiates User Plane (UP) Early Data Transmission (EDT) the ROHC is "continued" when UE initiates UP EDT, and if not present the UE resets the ROHC.
- nextHop chaining count – this is used to update eNB Key.
- PUR config – this configures Preconfigured Uplink Resources (PUR) for the UE to transmit data while in idle mode.
- CBP index – this is an index to the Coverage Based Paging (CBP) configuration.

When the UE receives a RRCConnectionRelease message, the UE waits for certain procedures before performing the actions for transitioning to RRC idle mode. This is done to ensure that the RRC release can be acknowledged, so that the network knows that the RRC release has been received correctly (this is different from *waitTime*). This reduces the likelihood of a state mismatch between the network and UE. This can be seen in the following part of the specification 3GPP TS 36.331:

---------- 3GPP TS 36.331 ----------

5.3.8.3 Reception of the *RRCConnectionRelease* by the UE

The UE shall:

1> except for NB-IoT, BL UEs or UEs in CE, delay the following actions defined in this clause 60 ms from the moment the *RRCConnectionRelease* message was received or optionally when lower layers indicate that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged, whichever is earlier;

1> for BL UEs or UEs in CE, delay the following actions defined in this clause 1.25 seconds from the moment the *RRCConnectionRelease* message was received or optionally when lower layers indicate that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged, whichever is earlier;

1> for NB-IoT, delay the following actions defined in this clause 10 seconds from the moment the *RRCConnectionRelease* message was received or optionally when lower layers indicate that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged, whichever is earlier.

NOTE 0: For BL UEs, UEs in CE and NB-IoT, when STATUS reporting, as defined in TS 36.322 [7], has not been triggered and the UE has sent positive HARQ feedback (ACK), as defined in TS 36.321 [6], the lower layers can be considered to have indicated that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged.

---------- 3GPP TS 36.331 ----------

Suspending the RRC connection triggers the following:

---------- 3GPP TS 36.331 ----------

1> if leaving RRC_CONNECTED was triggered by suspension of the RRC:

2> re-establish RLC entities for all SRBs and DRBs, including RBs configured with NR PDCP;

2> remove all entries within *VarConditionalReconfiguration*, if any;

2> for each *measId*, that is part of the current UE configuration in *VarMeasConfig*, if the associated *reportConfig* has *condReconfigurationTriggerEUTRA/condReconfigurationTriggerNR* configured:

3> remove the entry with the matching *reportConfigId* from the *reportConfigList* within the *VarMeasConfig*;

3> if the associated *measObjectId* is only associated with *condReconfigurationTriggerEUTRA/condReconfigurationTriggerNR*:

4> remove the entry with the matching *measObjectId* from the *measObjectList* within the *VarMeasConfig*;

3> remove the entry with the matching *measId* from the *measIdList* within the *VarMeasConfig*;

2> store the UE AS Context including the current RRC configuration, the current security context, the PDCP state including ROHC state, C-RNTI used in the source PCell, the *cellIdentity* and the physical cell identity of the source PCell, and the *spCellConfigCommon* within *ReconfigurationWithSync* of the PSCell (if configured);

2> store the following information provided by E-UTRAN:

3> if the UE connected to 5GC is a BL UE or UE in CE:

4> the *fullI-RNTI*, if present;

4> the *shortI-RNTI*, if present;

3> else:

4> the *resumeIdentity*;

3> the *nextHopChainingCount*, if present. Otherwise discard any stored *nextHopChainingCount* that does not correspond to stored key K_{RRCint};

3> the *drb-ContinueROHC*, if present. Otherwise discard any stored *drb-ContinueROHC*;

---------- 3GPP TS 36.331 ----------

RRC Release with redirection has the following actions:

---------- 3GPP TS 36.304 ----------

5.2.7a Cell Selection at transition to RRC_IDLE state for NB-IoT

At reception of *RRCConnectionRelease-NB* message or *RRCEarlyDataComplete-NB* message to move the UE into RRC_IDLE, UE shall attempt to camp on a suitable cell according to *redirectedCarrierInfo*, if included in the *RRCConnectionRelease-NB* message or *RRCEarlyDataComplete-NB* message. If the UE cannot find a suitable cell, the UE is allowed to camp on a suitable cell of any NB-IoT carrier. If the *RRCConnectionRelease-NB* message or *RRCEarlyDataComplete-NB* message does not contain the *redirectedCarrierInfo* UE shall attempt to select a suitable cell on a NB-IoT carrier.

---------- 3GPP TS 36.304 ----------

Overview of RRC Re-establishment

RRC Connection re-establishment is performed due to a number of reasons:

---------- 3GPP TS 36.331 ----------

5.3.7.2 Initiation

The UE shall only initiate the procedure either when AS security has been activated or for a NB-IoT UE supporting RRC connection re-establishment for the Control Plane CIoT EPS/5GS optimisation. The UE initiates the procedure when one of the following conditions is met:

1> upon detecting radio link failure and T316 is not configured, in accordance with 5.3.11; or

1> upon detecting radio link failure of the MCG while SCG transmission is suspended, in accordance with 5.3.11; or

1> upon detecting radio link failure of the MCG while NR PSCell change or PSCell addition is ongoing, in accordance with 5.3.11; or

1> upon handover failure, in accordance with 5.3.5.6; or

1> upon mobility from E-UTRA failure, in accordance with 5.4.3.5; or

1> except when resuming an RRC connection after early security reactivation in accordance with conditions in 5.3.3.18, upon integrity check failure indication from lower layers concerning SRB1 or SRB2; or

1> upon an RRC connection reconfiguration failure, in accordance with 5.3.5.5; or

1> upon an RRC connection reconfiguration failure, in accordance with TS38.331 [82], clause 5.3.5.8; or

1> upon detecting radio link failure for the SCG while MCG transmission is suspended, in accordance with TS 38.331 [82] clause 5.3.10.3 in (NG)EN-DC; or

1> upon SCG change failure while MCG transmission is suspended, in accordance with TS 38.331 [82] clause 5.3.5.8.3 in (NG)EN-DC; or

1> upon SCG configuration failure while MCG transmission is suspended in accordance with clause TS 38.331 [82] clause 5.3.5.8.2 in (NG)EN-DC; or

1> upon integrity check failure indication from SCG lower layers concerning SRB3 while MCG transmission is suspended; or

1> upon T316 expiry, in accordance with clause 5.6.26.5.

---------- 3GPP TS 36.331 ----------

Figure 2 illustrates a general RRC Re-establishment procedure [3GPP TS36.300 V17.2.0]. The procedure comprises the following steps:

1. Radio Link Failure is triggered at the UE.
2. The UE triggers the re-establishment procedures, including cell selection where a suitable cell is selected.
3. The UE sends an RRC Connection Reestablishment Request message to the selected cell (Target eNB). This message contains a UE identity (c-RNTI, physCellId and shortMAC-I) and a reestablishment cause.
4. The target eNB identifies the UE and determines that it has no UE context for the UE, so the target eNB requests this from the Source eNB in a RETRIEVE UE CONTEXT REQUEST message.
5. The source eNB replies to the message in step 4 by providing the UE context in a RETRIEVE UE CONTEXT RESPONSE message to the target eNB.
6. The target eNB replies to the message in step 3 with an RRC Connection Reestablishment message to the UE, which confirms the request and contains an RRC configuration for the UE.
7. The UE replies to the message in step 6 with an RRC Connection Re-establishment Complete message, and the UE may now start data communication.

Overview of T-Service

T-Service is a parameter specific to Non-Terrestrial Networks that is used in quasi-earth fixed cases to indicate a time when a satellite (cell) that is currently serving a specific area will stop serving that area. In particular, when the UE is in idle mode, the UE starts performing neighbour cell measurements before the indicated time. This ensures that the UE will have a cell to camp on when a quasi-earth fixed (satellite) cell stops serving the area.

The above information is presented as background information only to assist with an understanding of the present disclosure. No determination has been made, and no assertion is made, as to whether any of the above might be applicable as prior art with regard to the present invention.

SUMMARY

It is an aim of certain examples of the present disclosure to address, solve and/or mitigate, at least partly, at least one of the problems and/or disadvantages associated with the related art, for example at least one of the problems and/or disadvantages described herein. It is an aim of certain examples of the present disclosure to provide at least one advantage over the related art, for example at least one of the advantages described herein.

The present invention is defined in the independent claims. Advantageous features are defined in the dependent claims. Embodiments or examples disclosed in the description and/or figures falling outside the scope of the claims are to be understood as examples useful for understanding the present invention.

Other aspects, advantages and salient features of the invention will become apparent to those skilled in the art from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an exemplary scenario involving an RRC Connection Release procedure;

Figure 2 illustrates an exemplary RRC Re-establishment procedure;

Figure 3 illustrates an example of signalling a list of intra-RAT cells to which RRC connection establishment may be performed;

Figure 4 illustrates an example of signalling a validity time for cell (re-)selection configuration after RRCConnectionRelease;

Figure 5 illustrates an example of RRC Connection re-establishment after RRC Connection Release;

Figure 6 illustrates an example of indicating that release-based re-establishment has been performed;

Figure 7 illustrates an example of signalling a maximum time period for activating RRC Connection Release configuration;

Figure 8 illustrates an example of using T-Service to indicate a latest time for activating RRC Connection Release; and

Figure 9 is a block diagram of an exemplary network entity that may be used in certain examples of the present disclosure.

DETAILED DESCRIPTION

The following description of examples of the present disclosure, with reference to the accompanying drawings, is provided to assist in a comprehensive understanding of the present invention, as defined by the claims. The description includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the examples described herein can be made without departing from the scope of the invention.

The same or similar components may be designated by the same or similar reference numerals, although they may be illustrated in different drawings.

Detailed descriptions of techniques, structures, functions, operations or processes known in the art may be omitted for clarity and conciseness, and to avoid obscuring the subject matter of the present invention.

The terms and words used herein are not limited to the bibliographical or standard meanings, but, are merely used to enable a clear and consistent understanding of the invention.

Throughout the description and claims of this specification, the words “comprise”, “include” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other features, elements, components, integers, steps, processes, operations, functions, characteristics, properties and/or groups thereof.

Throughout the description and claims of this specification, the singular form, for example "a", "an" and "the", encompasses the plural unless the context otherwise requires. For example, reference to "an object" includes reference to one or more of such objects.

Throughout the description and claims of this specification, language in the general form of "X for Y" (where Y is some action, process, operation, function, activity or step and X is some means for carrying out that action, process, operation, function, activity or step) encompasses means X adapted, configured or arranged specifically, but not necessarily exclusively, to do Y.

Features, elements, components, integers, steps, processes, operations, functions, characteristics, properties and/or groups thereof described or disclosed in conjunction with a particular aspect, embodiment, example or claim are to be understood to be applicable to any other aspect, embodiment, example or claim described herein unless incompatible therewith.

The skilled person will appreciate that the techniques described herein may be used in any suitable combination.

Certain examples of the present disclosure provide one or more techniques for device mobility in a network. For example, certain examples of the present disclosure provide one or more techniques for IoT device mobility in a 3GPP NTN through connection release and connection establishment or re-establishment. However, the skilled person will appreciate that the present invention is not limited to these examples, and may be applied in any suitable system or standard, for example one or more existing and/or future generation wireless communication systems or standards, including any existing or future releases of the same standards specification, for example 3GPP 5G.

The functionality of the various network entities and other features disclosed herein may be applied to corresponding or equivalent entities or features in the same or any other suitable communication systems or standards. Corresponding or equivalent entities or features may be regarded as entities or features that perform the same or similar role, function or purpose within the network. For example, the functionality of a base station or the like (e.g. eNB, gNB, NB, RAN node, access point, wireless point, transmission/reception point, central unit, distributed unit, radio unit, remote radio head, etc.) in the examples below may be applied to any other suitable type of entity performing RAN functions, and the functionality of a UE or the like (e.g. electronic device, user device, mobile station, subscriber station, customer premises equipment, terminal, remote terminal, wireless terminal, vehicle terminal, etc.) in the examples below may be applied to any other suitable type of device.

A particular network entity may be implemented as a network element on a dedicated hardware, as a software instance running on a dedicated hardware, and/or as a virtualised function instantiated on an appropriate platform, e.g. on a cloud infrastructure.

The skilled person will appreciate that the present invention is not limited to the specific examples disclosed herein. For example:

- The techniques disclosed herein are not limited to 3GPP 5G.
- One or more entities in the examples disclosed herein may be replaced with one or more alternative entities performing equivalent or corresponding functions, processes or operations.
- One or more of the messages in the examples disclosed herein may be replaced with one or more alternative messages, signals or other type of information carriers that communicate equivalent or corresponding information.
- One or more further elements or entities may be added to the examples disclosed herein.
- One or more non-essential elements or entities may be omitted in certain examples.
- The functions, processes or operations of a particular entity in one example may be divided between two or more separate entities in an alternative example.
- The functions, processes or operations of two or more separate entities in one example may be performed by a single entity in an alternative example.
- Information carried by a particular message in one example may be carried by two or more separate messages in an alternative example.
- Information carried by two or more separate messages in one example may be carried by a single message in an alternative example.
- The order in which operations are performed and/or the order in which messages are transmitted may be modified, if possible, in alternative examples.

Certain examples of the present disclosure may be provided in the form of an apparatus/device/network entity configured to perform one or more defined network functions and/or a method therefor. Certain examples of the present disclosure may be provided in the form of a system (e.g. network or wireless communication system) comprising one or more such apparatuses/devices/network entities, and/or a method therefor.

As discussed above, one procedure for performing mobility in NB-IoT involves the UE declaring RLF. When this occurs the UE may need to measure and scan the frequencies of cells in order to find a suitable cell to re-establish to. However, this may take a long time.

In some cases, the network may have information to assist in the selection of a suitable cell, for example information relating to satellite orbit information (e.g. trajectories). It should be possible to release the UE to establish RRC connection to another cell to continue the service with the other cell. However RRCConnectionRelease is not optimized for cases where the UE needs to perform mobility, or when there is constant mobility.

For example, in response to receiving a RRCConnectionRelease message, a UE moves to idle mode. Then, the UE uses the RRC Connection establishment procedure to connect to another cell. However, this procedure may take a long time. Therefore, a procedure based on RRCConnectionRelease may not be suitable for mobility in some cases.

In LTE-M and NB-IoT, the UE may wait up to 1.25 and 10 seconds until the RRC Connection Release procedure starts after receiving the RRCConnectionRelease message. This length of delay may cause long service interruption. In addition, due to the delay, the radio situation of a LEO satellite deployment may be entirely different once the RRC Connection Release procedure is performed. For example, if the RRC Connection Release message contains frequency priorities of an upcoming satellite, if there is a long delay before the RRC release procedure starts, the frequency priorities may no longer be valid due to movement of the satellites and the corresponding cells.

Accordingly, certain examples of the present disclosure provide one or more techniques to enable an RRC connection release procedure to be used more effectively in NTN. Certain examples of the present disclosure provide one or more techniques that provide an alternative to performing a RLF procedure for mobility purposes.

The skilled person will appreciate that the various examples disclosed herein may be implemented using existing RRC messages (e.g. RRC Release) or any other suitable messages. The skilled person will appreciate that the names of messages may vary across different RATs, for example NR and LTE (E-UTRAN). For example, in 5G NR the release procedures are started by the *RRCRelease* message, whereas in E-UTRAN the corresponding name is *RRCConnectionRelease*. The skilled person will appreciate that examples disclosed herein referring to message names in one particular RAT (e.g. E-UTRAN) are not limited to that RAT, but may be applied to other RATs (e.g. NR).

The skilled person will appreciate that the various techniques disclosed herein may be applied to gNB and NG-RAN cases, and all related RRC signalling and/or messages, and to X2, Xn, S1, and NG signalling and messages, and/or related network entities (e.g. Mobility Management Entity (MME), Access and Mobility Management Function (AMF), other).

The skilled person will appreciate that the various techniques disclosed herein may be applied to IoT NTN and/or NR NTN.

In the present disclosure, references are made to the terms “base station” (an equivalent terms, such as NB, eNB, etc.) and “cell”. The skilled person will appreciate that a cell (or coverage area) may be associated with a base station. For example, a base station may provide network access to UEs within a coverage area of the base station defining a cell. In some cases, a base station may be associated with multiple cells. For example, two or more cells associated with different carrier frequencies may be provided by the same base station. In another example, an overall area serviced by a certain base station may be sectorized to form multiple cells. The skilled person will appreciate that certain information may be regarded as associated with a base station, with a cell corresponding to the base station, or with both the base station and the corresponding cell, depending on the type of information.

Certain examples of the present disclosure provide a method for a UE in a network comprising the UE and two or more base stations (NBs), the method comprising: receiving, from a first NB, a connection release message instructing the UE to release a connection with the first NB, wherein the connection release message includes information related to one or more other NBs, the information for performing a connection procedure; releasing the connection with the first NB in response to the connection release message; entering an idle mode; and performing the connection procedure to establish a connection with a second NB based on the information.

In certain examples, the information may comprise, for each of the one or more other NBs, one or more of: an ID of a cell associated with the NB; a carrier frequency associated with a cell associated with the NB; a carrier bandwidth associated with a cell associated with the NB; and a priority of a cell associated with the NB.

In certain examples, the method may further comprise selecting a cell associated with the second NB from among one or more cells associated with the one or more other NBs.

In certain examples, the method may further comprise determining a priority of one or more cells associated with the one or more other NBs.

In certain examples, the priority may be determined based on one or more of: a distance between the UE and a satellite associated with each NB; and a distance between the UE and a reference location associated with each NB and/or cell.

In certain examples, the information may be associated with a validity period.

In certain examples, the information may comprise an indication of the number of cells associated with other NBs.

In certain examples, the information may comprise a valid location for (i) the one or more other NBs and/or (ii) one or more cells associated with the one or more other NBs.

In certain examples, the connection procedure may comprise a connection establishment procedure or a connection re-establishment procedure.

In certain examples, the connection release message may comprise information indicating the type of connection procedure to perform.

In certain examples, the connection release message may comprise an indication to not perform the connection procedure.

In certain examples, performing the connection procedure may comprise indicating, to the second NB, a cause for performing the connection procedure.

In certain examples, the method may further comprise transmitting, by the second NB to the first NB, a message including one or more of: an indication that re-establishment has been performed; an identification of the second NB; and an indication of one or more NBs to which the UE attempted a connection.

In certain examples, the method may further comprise determining (e.g. receiving or obtaining) an indication of a time period, and releasing the connection may comprise releasing the connection the time period after receiving the connection release message.

In certain examples, the method may further comprise determining (e.g. receiving or obtaining) an indication of a time period, and releasing the connection may comprise releasing the connection before expiry of the time period.

In certain examples, the time period may be based on when a cell corresponding to the first NB will no longer serve a certain area in which the UE is located.

In certain examples, the indication of the time period may be determined based on (e.g. included in) one or more of: the connection release message; a connection setup message; system configuration; and broadcast signalling.

In certain examples, the method may further comprise applying an offset to the time period.

Certain examples of the present disclosure provide a method for a UE in a network comprising the UE and one or more base stations (NBs), the method comprising: receiving, from a first

NB, a connection release message instructing the UE to release a connection with the first NB; determining (e.g. receiving or obtaining) time information; and releasing the connection with the first NB in response to the connection release message, wherein the connection is released at a time based on the time information.

In certain examples, the time information may include a time period, and the connection may be released the time period after receiving the connection release message.

In certain examples, the time information may include a time period, and the connection may be released before expiry of the time period.

In certain examples the time period may be based on when a cell corresponding to the first NB will no longer serve a certain area in which the UE is located.

In certain examples, the time information may be determined based on (e.g. included in) one or more of: the connection release message; a connection setup message; system configuration; and broadcast signalling.

In certain examples, the method may further comprise entering an idle mode.

In certain examples, the connection release message may include information related to one or more cells associated with one or more other NBs, the information for performing a connection procedure, and the method may further comprise performing the connection procedure to establish a connection with a second NB based on the information.

Certain examples of the present disclosure provide a UE configured to perform a method according to any example, aspect, embodiment and/or claim disclosed herein.

In certain examples, the UE may be an IoT device.

Certain examples of the present disclosure provide a network (or wireless communication system) comprising a base station according to any example, aspect, embodiment and/or claim disclosed herein and a UE according to any example, aspect, embodiment and/or claim disclosed herein.

In certain examples, the network may comprise an NTN.

Certain examples of the present disclosure provide a computer program comprising instructions which, when the program is executed by a computer or processor, cause the computer or processor to carry out a method according to any example, aspect, embodiment and/or claim disclosed herein.

Certain examples of the present disclosure provide a computer or processor-readable data carrier having stored thereon a computer program according to any example, aspect, embodiment and/or claim disclosed herein.

Various examples will now be described in more detail.

RRC release procedure

In certain examples, the RRC Connection Release procedure may be used for mobility purposes. In this case, one or more new elements, behaviour and/or signalling/messages may be introduced. For example, certain examples may introduce one or more new Release causes. In certain examples, one or more existing elements and/or behaviours and/or signalling/messages may be enhanced/extended/modified/optimised.

In certain examples, the network may signal that the UE shall perform establishment upon finding a suitable cell (through idle mode cell (re-)selection), signalled in the RRC Connection Release message.

In certain examples, the network may signal a set of one or more intra-RAT cells (e.g. in the *RRCConnectionRelease* message) that the UE should select and perform RRC establishment to, if required. These cells may be indicated in a list of cells, which includes, for example, the physical cell ID, the carrier frequency and/or the carrier bandwidth. In certain examples other assistance information related to a cell (e.g. SIB31 information) may be provided. Figure 3 illustrates an example of signalling a list of intra-RAT cells to which RRC connection establishment may be performed.

Referring to Figure 3, in a first operation S301, a first eNB (eNB_1) 20 decides to release a connection with a UE 10.

In a second operation S302, the first eNB 20 transmits a first message to the UE 10 in response to the release decision. For example, the first message may comprise an RRCConnectionRelease message. The first message may comprise information indicating a set of one or more intra-RAT cells that the UE 10 should select and perform RRC establishment to, if required. For example, the information may comprise a physical cell ID, carrier frequency and/or carrier bandwidth of each cell.

In a third operation, S303, the UE 10 enters idle mode in response to receiving the first message.

In a fourth operation, S304, the UE 10 performs cell selection or cell re-selection. For this operation, the UE 10 may use the information contained in the first message to assist in the selection of a cell.

In a fifth operation S305, the UE 10 establishes a connection with the selected cell/eNB. In the example of Figure 3, the UE 10 has selected a second eNB (eNB_2) 30, which is different from the first eNB (eNB_1) 20. The fifth operation S305 may include transmission of one or more messages between the UE 10 and the selected eNB (e.g. transmission of one or more messages from UE to eNB and/or transmission of one or more messages from eNB to UE), including transmission of a second message, for example an RRC Connection establishment message, from the UE 10 to the selected eNB, to establish the connection.

In certain examples, the network may signal a list of E-UTRAN carrier frequencies, the corresponding priorities and/or physical cell IDs. This may allow the inter-frequency procedures to remain the same, but also facilitates cell selection as the UE only has to detect a single cell at each frequency. In certain examples, the network may also signal radio configurations (radioResourceConfigCommon) or any other suitable information needed for performing establishment to one of the cells without reading the related information (e.g. SIB2 information). This means that the UE may not have to read relevant system information (e.g. SIB1 or SIB2) before establishing a connection to that specific cell (although in certain examples the relevant system information may be read based on certain other conditions and/or circumstances).

In certain examples, the UE does not perform cell (re-)selection measurements of the signalled cells, but rather directly performs establishment to one of the cells.

In certain examples, if the network includes information related to a list of cells that the UE should select and perform RRC (re-)establishment to, for example in the RRCConnectionRelease message, but the UE determines that none of the cells meet the legacy cell (re-)selection criteria, the UE may ignore the indicated cell list and/or the UE should search for a suitable cell to camp on following normal procedure and using the legacy priorities that are for instance signalled in the system information.

In certain examples, when receiving an RRCConnectionRelease message, a frequency priority of different cells may be decided based on any suitable information (e.g. NTN specific information). For example, this information may include information for determining a distance between the UE and a cell, which may be used to determine which of the cells is closest to the UE. For example, the distance may be determined based on the distance between the UE

and the satellite associated with the cell and/or the distance between the UE and a reference location associated with the cell.

In certain examples, the network may provide satellite/NTN ephemeris information. For example, this may be provided through an NTN-specific SystemInformationBlock (e.g. SIB31).

In certain examples, the configuration used to establish to another set of cells may be deemed valid for only a certain amount of time. For example, as a satellites move, the signalled information may not be valid or useful in the future. When the information is no longer valid, the UE may search for a cell to camp on according to another procedure, for example using legacy priorities that may be signalled in the system information for example. Figure 4 illustrates an example of signalling a validity time for cell (re-)selection configuration after RRCConnectionRelease.

Referring to Figure 4, in a first operation S401, a first eNB (eNB_1) 20 decides to release a connection with a UE 10.

In a second operation S402, the eNB 10 transmits a first message to the UE 10 in response to the release decision. For example, the first message may comprise an RRCConnectionRelease message. The first message may comprise time information indicating a time period corresponding to a validity time of configuration/information used to establish to one or more cells. For example, the configuration may comprise the information provided in the second operation S302 of Figure 3.

In a third operation, S403, the UE 10 enters idle mode in response to receiving the first message.

In a fourth operation, S404, the UE 10 performs cell selection or cell re-selection. For this operation, the UE 10 may use configuration/information which remains valid according to the time information received in the second operation S402.

In a fifth operation S405, the UE 10 establishes a connection with the selected cell/eNB. In the example of Figure 4, the UE 10 has selected a second eNB (eNB_2) 30, which is different from the first eNB (eNB_1) 20. The fifth operation S405 may include transmission of one or more messages between the UE 10 and the selected eNB (e.g. transmission of one or more messages from UE to eNB and/or transmission of one or more messages from eNB to UE), including transmission of a second message, for example an RRC Connection establishment message, from the UE 10 to the selected eNB, to establish the connection.

In certain examples, the network may not indicate a specific set of cells that should be considered for camping on, but rather the maximum number of cells expected to be available. This can allow for power saving at the UE if there are only a few number of cells. For example, in some IoT NTN scenarios there may be only one cell per satellite.

In certain examples, the network may signal one or more validity locations for certain cells. For example, the network may indicate that a first set of cells are valid in a first country, while a second set of cells are valid in a second country. The UE may then determine in the cell (re-)selection procedure which cells to use based on the country in which the UE is located. This may be advantageous in NB-IoT since the network may not know the exact location of the UE.

RRC re-establishment

In certain examples, the network may signal to the UE to perform RRC re-establishment if the UE finds a new cell after receiving the RRCConnectionRelease message. For example, this may be signalled in the Release cause. In certain examples, the signalling may be in the form of a flag or other indication in the RRCConnectionRelease message, where a first predetermined value (e.g. "1") indicates enable (i.e. to perform re-establishment), and a second predetermined value (e.g. "0") indicates disabled (i.e. to not perform re-establishment). This may provide an advantage compared to performing RRC establishment. For example, the UE may start operating without needing to have its RRC configuration setup, and the AS security can be maintained, achieving lower latency and lower power consumption due to less overhead.

In certain examples, the network may signal to the UE that either establishment (RRC Connection Establishment) or re-establishment (RRC Connection Re-establishment) should be performed. For example, this may be signalled in the RRC Release message. In certain examples, the signalling may be in the form of an information field in the RRCConnectionRelease message, where a first predetermined value (e.g. "2") indicates enable (i.e. to perform re-establishment), a second predetermined value (e.g. "1") indicates to perform establishment (i.e. to not perform re-establishment), and a third predetermined value (e.g. "0") indicates none of the above or "disabled".

In certain examples, when the UE performs RRC re-establishment, after having received RRC Connection Release message, the UE may include a predetermined RRC re-establishment cause in the *RRCConnectionReestablishmentRequest* message that indicates that the UE is performing re-establishment in response to receiving a RRC Connection Release message. In certain examples, the RRC Connection Release cause may be a newly defined cause value, for example "ReleaseToOtherCell", or any other suitable naming. Figure 5 illustrates an

example of RRC Connection re-establishment after RRC Connection Release including an RRC re-establishment cause.

Referring to Figure 5, in a first operation S501, a first eNB (eNB_1) 20 decides to release a connection with a UE 10.

In a second operation S502, the first eNB 20 transmits a first message to the UE 10 in response to the release decision. For example, the first message may comprise an RRCConnectionRelease message. The first message may comprise information indicating that the UE 10 should perform establishment or re-establishment. The first message may also comprise any other suitable information, for example configuration information as described above in relation to Figure 3 and/or time information as described above in relation to Figure 4.

In a third operation, S503, the UE 10 enters idle mode in response to receiving the first message.

In a fourth operation, S504, the UE 10 performs cell selection or cell re-selection. For example, the fourth operation S504 may be performed according to the fourth operation S304 of Figure 3 and/or the fourth operation S404 of Figure 4, but is not limited to these examples.

In a fifth operation S505, the UE 10 establishes a connection with the selected cell/eNB. In the example of Figure 5, the UE 10 has selected a second eNB (eNB_2) 30, which is different from the first eNB (eNB_1) 20. The fifth operation S405 may include transmission of one or more messages between the UE 10 and the selected eNB (e.g. transmission of one or more messages from UE to eNB and/or transmission of one or more messages from eNB to UE), including transmission of a second message, for example an RRC Connection establishment message, from the UE 10 to the selected eNB, to establish the connection. The second message may include information indicating that the UE 10 is performing re-establishment (or establishment in other examples) in response to receiving the first message (e.g. RRCConnectionRelease message). For example, the information may comprise a certain cause value, for example indicating “ReleaseToOtherCell”.

In certain examples, if the network includes a legacy RRC release cause, the UE may ignore the legacy release cause if RRC re-establishment is signalled to be performed.

In certain examples, the new eNB (e.g. eNB_2) to which the UE has performed re-establishment may inform the old eNB (e.g. eNB_1) that re-establishment following a RRC Connection Release has been performed. In certain examples, the new eNB may provide the old eNB with any suitable other information, for example information indicating which cells

were signalled, which cells the UE attempted to connect to, which cell the UE successfully connected to. Figure 6 illustrates an example of indicating that release-based re-establishment has been performed.

Referring to Figure 6, first to fifth operations S601 to S605 respectively correspond to first to fifth operations S501 to S505 of Figure 5, and so detailed description of Steps S601 to S605 are omitted for conciseness.

In a sixth operation S606, the second eNB (eNB_2) 30 transmits a third message to the first eNB (eNB_1) 20. The third message includes information indicating that release-based re-establishment has been performed.

Example 1:

---------- 3GPP TS 36.331 ----------

– RRCConnectionRelease-NB

The *RRCConnectionRelease-NB* message is used to command the release of an RRC connection, or to complete an UP-EDT procedure.

Signalling radio bearer: SRB1 or SRB1bis

RLC-SAP: AM

Logical channel: DCCH

Direction: E-UTRAN to UE

***RRCConnectionRelease-NB* message**

```
-- ASN1START

RRCConnectionRelease-NB ::=     SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            rrcConnectionRelease-r13            RRCConnectionRelease-NB-r13-IEs,
            spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionRelease-NB-r13-IEs ::= SEQUENCE {
    releaseCause-r13                    ReleaseCause-NB-r13,
    resumeIdentity-r13                  ResumeIdentity-r13              OPTIONAL,   -- Need OR
    extendedWaitTime-r13                INTEGER (1..1800)               OPTIONAL,   -- Need ON
    redirectedCarrierInfo-r13           RedirectedCarrierInfo-NB-r13    OPTIONAL,   -- Need ON
    lateNonCriticalExtension            OCTET STRING                    OPTIONAL,
    nonCriticalExtension                RRCConnectionRelease-NB-v1430-IEs       OPTIONAL
}

                                        ...Omitted...

ReleaseCause-NB-r13 ::=             ENUMERATED {loadBalancingTAUrequired, other,
                                                rrc-Suspend, ~~cs-Fallback~~releaseToOtherCell-r14}

                                        ...Omitted...

-- ASN1STOP
```

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Example 2:

---------- 3GPP TS 36.331 ----------

– RRCConnectionReestablishmentRequest-NB

The *RRCConnectionReestablishmentRequest-NB* message is used to request the reestablishment of an RRC connection.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: CCCH

Direction: UE to E-UTRAN

***RRCConnectionReestablishmentRequest-NB* message**

```
-- ASN1START

RRCConnectionReestablishmentRequest-NB ::= SEQUENCE {
    criticalExtensions                  CHOICE {
        rrcConnectionReestablishmentRequest-r13
                                            RRCConnectionReestablishmentRequest-NB-r13-IEs,
        later                               CHOICE {
            rrcConnectionReestablishmentRequest-r14
                                            RRCConnectionReestablishmentRequest-NB-r14-IEs,
            later                           CHOICE {
                rrcConnectionReestablishmentRequest-r16
                                            RRCConnectionReestablishmentRequest-5GC-NB-r16-
IEs,
                criticalExtensionsFuture    SEQUENCE {}
            }
        }
    }
}

RRCConnectionReestablishmentRequest-NB-r13-IEs ::= SEQUENCE {
    ue-Identity-r13                     ReestabUE-Identity,
    reestablishmentCause-r13            ReestablishmentCause-NB-r13,
    cqi-NPDCCH-r14                      CQI-NPDCCH-NB-r14,
    earlyContentionResolution-r14       BOOLEAN,
    spare                               BIT STRING (SIZE (20))
}

RRCConnectionReestablishmentRequest-NB-r14-IEs ::= SEQUENCE {
    ue-Identity-r14                     ReestabUE-Identity-CP-NB-r14,
    reestablishmentCause-r14            ReestablishmentCause-NB-r13,
    cqi-NPDCCH-r14                      CQI-NPDCCH-Short-NB-r14,
    earlyContentionResolution-r14       BOOLEAN,
    spare                               BIT STRING (SIZE (1))
}

RRCConnectionReestablishmentRequest-5GC-NB-r16-IEs ::= SEQUENCE {
    ue-Identity-r16                     ReestabUE-Identity-CP-5GC-NB-r16,
    reestablishmentCause-r16            ReestablishmentCause-NB-r13,
    cqi-NPDCCH-r16                      CQI-NPDCCH-Short-NB-r14,
    spare                               BIT STRING (SIZE (1))
}

ReestablishmentCause-NB-r13 ::=         ENUMERATED {
                                            reconfigurationFailure, otherFailure,
                                            ~~~~~~~~releasedToOtherCell-r16, spare1}

ReestabUE-Identity-CP-NB-r14 ::=        SEQUENCE {
    s-TMSI-r14                              S-TMSI,
    ul-NAS-MAC-r14                          BIT STRING (SIZE (16)),
    ul-NAS-Count-r14                        BIT STRING (SIZE (5))
}
```

```
ReestabUE-Identity-CP-5GC-NB-r16 ::=    SEQUENCE {
    truncated5G-S-TMSI-r16                  BIT STRING (SIZE (40)),
    ul-NAS-MAC-r16                          BIT STRING (SIZE (16)),
    ul-NAS-Count-r16                        BIT STRING (SIZE (5))
}

-- ASN1STOP
```

***RRCConnectionReestablishmentRequest-NB* field descriptions**
earlyContentionResolution Value TRUE indicates UE supports MAC PDU containing the UE contention resolution identity MAC control element without RRC response message. This field is always set to TRUE in this version of the specification.
reestablishmentCause Indicates the failure cause that triggered the re-establishment procedure. eNB is not expected to reject a *RRCConnectionReestablishmentRequest* due to unknown cause value being used by the UE.
truncated5G-S-TMSI For description of this field see TS 23.003 [27].
ue-Identity UE identity included to retrieve UE context and to facilitate contention resolution by lower layers.
ul-NAS-Count For description of this field see TS 33.401 [32] for EPC, and TS 33.501 [86] for 5GC.
ul-NAS-MAC For description of this field see TS 33.401 [32] for EPC, and TS 33.501 [86] for 5GC.

---------- 3GPP TS 36.331 ----------

Performing the RRC Connection release procedure

In order to ensure that the UE applies the RRC Connection Release configuration at an appropriate time, certain examples provide one or more techniques for determining when the UE applies the configuration.

In certain examples, the network may signal a time when the UE should perform the RRC Connection Release procedure. For example, this may be a value indicating a time period (e.g. from 1 to 10 seconds). The time period may be indicated using a certain Information Element (IE) (e.g. a newly defined IE, for example *releaseActivationTime* IE or any other suitable name). For example, the IE may be included in the RRC Connection Setup message or in the RRC Connection Release message.

In the case of providing the configured value in RRC Connection Release message, the network may not know what value the UE applies, for example if the configured value overrides an existing value (e.g. a previously configured value, or a hardcoded value such as the case in both E-UTRAN and NR). On the other hand, when the network configures a value using the RRC Connection Setup message, the network will know that the UE shall apply this value as the RRC Connection Setup is always acknowledged. Accordingly, in certain examples, the network may configure the *releaseActivationTime* using the RRC Connection Setup message.

Figure 7 illustrates an example of signalling a time period (e.g. maximum time period) for activating RRC Connection Release configuration.

Referring to Figure 7, in a first operation S701, a first eNB (eNB_1) 20 transmits a first message to a UE 10. The first message includes time information (e.g. releaseActivationTime) indicating a time by which the UE 10 should perform a connection release procedure.

In a second operation S702, the first eNB 20 decides to release a connection with the UE 10.

In a third operation S703, the first eNB 20 transmits a second message to the UE 10 in response to the release decision. For example, the second message may comprise an RRCConnectionRelease message. The second message may comprise any suitable information, for example one or more items of information as described above in relation to the first message of Figures 3 to 6.

In a fourth operation, S704, the UE 10 enters idle mode in response to receiving the second message. The UE 10 enters the idle mode and/or activates/applies connection release configuration information (e.g. configuration received in the second message) no later than a certain time period after receiving the second message, where the time period is derived from, or indicated by, the time information in the first message.

In certain examples, the *releaseActivationTime* may be configured via broadcast signalling.

In certain examples, the UE may apply the RRC Connection Release configuration before a time based on T-Service, or based on any other suitable timing information, configuration, parameter and/or threshold, for example related to NTN operation. Accordingly, the UE does not wait too long before activating the RRC Connection Release. In addition, with this technique, the network does not need to release the UE a relatively long time period (e.g. 10 seconds) in advance to ensure that the UE performs the RRC Connection Release on time. Figure 8 illustrates an example of using T-Service to indicate a latest time for activating RRC Connection Release.

Referring to Figure 8, in a first operation S801, a first eNB (eNB_1) 20 transmits a first message to a UE 10. The first message includes time information (e.g. T-Service) indicating a time point by which the UE 10 should perform a connection release procedure. For example, the time point may be based on a time when the first eNB 20 (e.g. a satellite-based/quasi-earth-fixed cell) that is currently serving the UE 10 (i.e. currently serving an area in which the UE 10 is located) will stop serving the UE 10 (i.e. will stop serving the area in which the UE 10 is located).

In a second operation S802, the first eNB 20 decides to release a connection with the UE 10.

In a third operation S803, the first eNB 20 transmits a second message to the UE 10 in response to the release decision. For example, the second message may comprise an RRCConnectionRelease message. The second message may comprise any suitable information, for example one or more items of information as described above in relation to the first message of Figures 3 to 7.

In a fourth operation, S804, the UE 10 enters idle mode in response to receiving the second message. The UE 10 enters the idle mode and/or activates/applies connection release configuration information (e.g. configuration received in the second message) no later than a certain time point, where the time point is derived from, or indicated by, the time information in the first message.

The skilled person will appreciate that certain examples may apply different items of time information in combination, for example first time information described in relation to Figure 7 (e.g. defining a first time by which the UE 10 should perform a certain operation, with reference to a certain time period starting from receipt of a certain message) and second time information described in relation to Figure 8 (e.g. defining a second time by which the UE 10 should perform a certain operation, with reference to a certain time point). In this case, the UE 10 may be configured to perform the certain operation (e.g. a connection release procedure and/or related operation(s)) no later than (i) the earliest of the first time and the second time, or (ii) the latest of the first time and the second time. The different items of time information may be communicated in the same or different messages in various examples. In the various examples disclosed herein, time information may be provided using any other suitable technique, for example it may be pre-configured or may be part of system configuration.

In certain examples, an offset may be added to T-Service to signal further granularity of when to activate the RRC Connection Release procedure. This may be advantageous in some cases, for example as the T-Service is in the granularity of seconds in E-UTRAN.

In certain examples, the time at which to perform actions related to RRC Connection Release may depend on the deployment. For example, if the network is a GEO NTN the time may be pre-configured to be a certain amount, if the network is a Medium Earth Orbit (MEO) NTN the time may be pre-configured to be a lower amount, and if the network is a LEO NTN the already pre-configured value may be applied.

Figure 9 is a block diagram of an exemplary network entity that may be used in examples of the present disclosure. For example, a UE and/or eNB/gNB in the examples of Figures 1-8 may comprise an entity of Figure 9. The skilled person will appreciate that a network entity may be implemented, for example, as a network element on a dedicated hardware, as a software instance running on a dedicated hardware, and/or as a virtualised function instantiated on an appropriate platform, e.g. on a cloud infrastructure.

The entity 900 comprises a processor (or controller) 901, a transmitter 903 and a receiver 905. The receiver 905 is configured for receiving one or more messages from one or more other network entities, for example as described above. The transmitter 903 is configured for transmitting one or more messages to one or more other network entities, for example as described above. The processor 901 is configured for performing one or more operations, for example according to the operations as described above.

The techniques described herein may be implemented using any suitably configured apparatus and/or system. Such an apparatus and/or system may be configured to perform a method according to any aspect, embodiment, example or claim disclosed herein. Such an apparatus may comprise one or more elements, for example one or more of receivers, transmitters, transceivers, processors, controllers, modules, units, and the like, each element configured to perform one or more corresponding processes, operations and/or method steps for implementing the techniques described herein. For example, an operation/function of X may be performed by a module configured to perform X (or an X-module). The one or more elements may be implemented in the form of hardware, software, or any combination of hardware and software.

It will be appreciated that examples of the present disclosure may be implemented in the form of hardware, software or any combination of hardware and software. Any such software may be stored in the form of volatile or non-volatile storage, for example a storage device like a ROM, whether erasable or rewritable or not, or in the form of memory such as, for example, RAM, memory chips, device or integrated circuits or on an optically or magnetically readable medium such as, for example, a CD, DVD, magnetic disk or magnetic tape or the like.

It will be appreciated that the storage devices and storage media are embodiments of machine-readable storage that are suitable for storing a program or programs comprising instructions that, when executed, implement certain examples of the present disclosure. Accordingly, certain examples provide a program comprising code for implementing a method, apparatus or system according to any example, embodiment, aspect and/or claim disclosed herein, and/or a machine-readable storage storing such a program. Still further, such

programs may be conveyed electronically via any medium, for example a communication signal carried over a wired or wireless connection.

While the invention has been shown and described with reference to certain examples, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention, as defined by the appended claims.

Abbreviations/Definitions

In the present disclosure, the following acronyms/definitions are used.

3GPP	3rd Generation Partnership Project
5G	5th Generation
5GC	5G Core
5GS	5G System
ACK	Acknowledge
AM	Acknowledged Mode
AMF	Access and Mobility management Function
AS	Access Stratum
BL	Bandwidth-reduced Low-complexity
CA	Carrier Aggregation
CCCH	Common Control Channel
CDMA	Code Division Multiple Access
CE	Coverage Enhancement
CIoT	Cellular IoT
CN	Core Network
C-RNTI	Cell RNTI
CS	Circuit Switched
DC	Dual Connectivity
DCCH	Dedicated Control Channel
DRB	Data Radio Bearer
EDGE	Enhanced Data rates for Global Evolution
EDT	Early Data Transmission
eMTC	enhanced Machine Type Communication
EN	E-UTRAN NR
eNB	Base Station
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GEO	Geosynchronous Equatorial Orbit
GERAN	GSM EDGE Radio Access Network
gNB	5G Base Station
GSM	Groupe Spécial Mobile
HAPS	High Altitude Platform Station
HARQ	Hybrid Automatic Repeat Request
ID	Identity/Identification
IE	Information Element
IoT	Internet of Things
LEO	Lower Earth Orbit
LTE	Long Term Evolution
LTE-M	LTE Machine Type Communication
MAC	Medium Access Control
MCG	Master Cell Group
MEO	Medium Earth Orbit
MME	Mobility Management Entity
NAS	Non Access Stratum
NB	Narrow Band
NB	Base Station
NG	Next Generation
NR	New Radio

NTN	Non-Terrestrial Network
PCell	Primary Cell
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PSCell	Primary and Secondary Cells
RAN	Radio Access Network
RAT	Radio Access Technology
RB	Radio Bearer
RLC	Radio Link Control
RLF	Radio Link Failure
RNTI	Radio Network Temporary Identifier
ROHC	Robust Header Compression
RRC	Radio Resource Control
S1	Interface between RAN and CN
SAP	Service Access Point
SCG	Secondary Cell Group
SIB	System Information Block
SRB	Signalling Radio Bearer
S-TMSI	Short TMSI
TAU	Tracking Area Update
TM	Transparent Mode
TMSI	Temporary Mobile Subscriber Identity
TN	Terrestrial Network
TS	Technical Specification
Txxx	Timer xxx
UE	User Equipment
UP	User Plane
X2/Xn	Interface between RAN nodes

Claims

1. A method for a User Equipment (UE) in a network comprising the UE and two or more base stations (NBs), the method comprising:

receiving, from a first NB, a connection release message instructing the UE to release a connection with the first NB, wherein the connection release message includes information related to one or more other NBs, the information for performing a connection procedure;

releasing the connection with the first NB in response to the connection release message;

entering an idle mode; and

performing the connection procedure to establish a connection with a second NB based on the information.

2. A method according to claim 1, wherein the information comprises, for each of the one or more other NBs, one or more of:

an ID of a cell associated with the NB;

a carrier frequency associated with a cell associated with the NB;

a carrier bandwidth associated with a cell associated with the NB; and

a priority of a cell associated with the NB.

3. A method according to claim 1 or 2, further comprising selecting a cell associated with the second NB from among one or more cells associated with the one or more other NBs.

4. A method according to claim 3, further comprising determining a priority of one or more cells associated with the one or more other NBs.

5. A method according to claim 4, wherein the priority is determined based on one or more of:

a distance between the UE and a satellite associated with each NB; and

a distance between the UE and a reference location associated with each NB and/or cell.

6. A method according to any preceding claim, wherein the information is associated with a validity period.

7. A method according to any preceding claim, wherein the information comprises an indication of the number of cells associated with other NBs.

8. A method according to any preceding claim, wherein the information comprises a valid location for (i) the one or more other NBs and/or (ii) one or more cells associated with the one or more other NBs.

9. A method according to any preceding claim, wherein the connection procedure comprises a connection establishment procedure or a connection re-establishment procedure.

10. A method according to any preceding claim, wherein the connection release message comprises information indicating the type of connection procedure to perform.

11. A method according to any preceding claim, wherein the connection release message comprises an indication to not perform the connection procedure.

12. A method according to any preceding claim, wherein performing the connection procedure comprises indicating, to the second NB, a cause for performing the connection procedure.

13. A method according to any preceding claim, further comprising transmitting, by the second NB to the first NB, a message including one or more of:

an indication that re-establishment has been performed;

an identification of the second NB; and

an indication of one or more NBs to which the UE attempted a connection.

14. A method according to any preceding claim, further comprising determining an indication of a time period, wherein releasing the connection comprises releasing the connection the time period after receiving the connection release message.

15. A method according to any preceding claim, further comprising determining an indication of a time period, wherein releasing the connection comprises releasing the connection before expiry of the time period.

16. A method according to claim 15, wherein the time period is based on when a cell corresponding to the first NB will no longer serve a certain area in which the UE is located.

17. A method according to claim 14, 15 or 16, wherein the indication of the time period is determined based on one or more of:

the connection release message;

a connection setup message;

system configuration; and

broadcast signalling.

18. A method according to any of claims 14 to 17, further comprising applying an offset to the time period.

19. A method for a User Equipment (UE) in a network comprising the UE and one or more base stations (NBs), the method comprising:

receiving, from a first NB, a connection release message instructing the UE to release a connection with the first NB;

determining time information; and

releasing the connection with the first NB in response to the connection release message, wherein the connection is released at a time based on the time information.

20. A method according to claim 19, wherein the time information includes a time period, and wherein the connection is released the time period after receiving the connection release message.

21. A method according to claim 19 or 20, wherein the time information includes a time period, and wherein the connection is released before expiry of the time period.

22. A method according to claim 21, wherein the time period is based on when a cell corresponding to the first NB will no longer serve a certain area in which the UE is located.

23. A method according to any of claims 19 to 22, wherein the time information is determined based on one or more of:

the connection release message;

a connection setup message;

system configuration; and

broadcast signalling.

24. A method according to any of claims 19 to 23, wherein the method further comprises entering an idle mode.

25. A method according to any of claims 19 to 24, wherein the connection release message includes information related to one or more cells associated with one or more other NBs, the information for performing a connection procedure, and wherein the method further comprises performing the connection procedure to establish a connection with a second NB based on the information.

26. A UE configured to perform a method according to any preceding claim.

27. A UE according to claim 26, wherein the UE is an IoT device.

28. A network (or wireless communication system) comprising a base station and a UE according to claim 26 or 27.

29. A network according to claim 28, wherein the network comprises an NTN.

30. A computer program comprising instructions which, when the program is executed by a computer or processor, cause the computer or processor to carry out a method according to any of claims 1 to 25.

31. A computer or processor-readable data carrier having stored thereon a computer program according to claim 30.

Intellectual Property Office

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Claims searched:	1-18 & (in part) 26-31	**Date of search:**	17 June 2024

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-8 & 26-31	WO 2019/137949 A1 (SONY) see pp. 10-11 and figs. 3-6
X	1-8 & 26-31	EP 3826422 A1 (ERICSSON) see fig. 6, [0061-0071] and [0078-0079]
X	1-8 & 26-31	CN 115499886 A (HUAWEI) see fig. 5 and its associated description
X,E	1 at least	WO 2024/030818 A1 (QUALCOMM) see fig. 8 and [0120-0128]
X,E	1 at least	WO 2024/031072 A1 (QUALCOMM) see fig. 8 and [0098-0100]

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

H04B; H04W

The following online and other databases have been used in the preparation of this search report

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International Classification:

Subclass	Subgroup	Valid From
H04W	0076/30	01/01/2018
H04W	0036/08	01/01/2009
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