**3GPP TSG SA WG2 Meeting #143ES2-2100246 r01**

**Elbonia, 24 February – 9 March 2021 (revision of S2-210xxxx)**

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| *CR-Form-v12.1* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **23.501** | **CR** | **2546** | **rev** | **-** | **Current version:** | **16.7.0** |  |
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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 |  | Core Network | **X** |

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| ***Title:*** | Correction of UE radio capability handling | | | | | | | | | |
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| ***Source to WG:*** | Apple | | | | | | | | | |
| ***Source to TSG:*** | C1 | | | | | | | | | |
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| ***Work item code:*** | 5GS\_Ph1; TEI16; 5G\_SRVCC | | | | |  | ***Date:*** | | | 2021-02-24 |
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| ***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-15 (Release 15) Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18)* | |
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| ***Reason for change:*** | | 1) According to clause 5.4.4.1, the UE is required to inform the network when the UE's "NG-RAN UE Radio Capability information" changes by performing a Registration procedure.  In other sentences in clause 5.4.4.1, the specification is just referring to a "UE Radio Capability information", so it is unclear whether "NG-RAN UE Radio Capability" is referring  i) to a specific subset of the UE Radio Capabilities, i.e. only to those parameters relevant for NR and E-UTRA connected to 5GC, or  ii) to all radio capabilities.  Actually, if a parameter relevant for E-UTRA connected to EPC is changing, this can be important for a subsequent inter-system handover to EPS, e.g. during EPS fallback. In worst case, providing an outdated radio capability to the target eNB could result in a handover failure. So any change of the UE's E-UTRA UE Radio Capability should be reported, and interpretation i) is not correct.  2) But also the alternative interpretation ii) that the UE should report all changes of its UE Radio Capability information is not correct, because starting with Rel-16, for a UE supporting SRVCC to UTRA-FDD, the UE Radio Capability information will also include UTRA Radio Capability information for SRVCC handover to UTRA-FDD:  RAN2 recently agreed CR 38.300-0317r3 (R2-2011231) which clarifies that due to a possible desynchronization of dynamic UMTS security parameters (START-CS) in the UTRA Radio Capability, the gNB does not upload the UE UTRA-FDD capabilities to the AMF. Prior to handover to UTRA-FDD, the gNB will always request the latest UE UTRA-FDD capabilities (see LS from RAN2 in S2-2100009/ R2-2011164). (This is similar to what is specified by SA2 in TS 23.401 and RAN2 in TS 36.300 for EPS.)  As a consequence, the UE does not need to inform the network of any changes in its UTRA UE Radio Capability information. Indeed, the UE should avoid this, as the NG-RAN would always request the whole UE Radio Capability information for NR and E-UTRA, and this would only create unnecessary signalling via the radio interface.  In sum, the specification should refer to the UE's NR and E-UTRA UE Radio Capability instead of NG-RAN UE Radio Capability.  3) The issue of item 1) applies also to the case when the UE changes its E-UTRA Radio Capability while it is in CM-CONNECTED mode.  4) It is proposed to document the special handling of the UTRA UE Radio Capability information described in the LS from RAN2 in clause 5.4.4.1 (in a similar way as it was documented for EPS in TS 23.401). | | | | | | | | |
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| ***Summary of change:*** | | 1+2+3) "NG-RAN UE Radio Capability" is replaced with "NR and E-UTRA UE Radio Capability".  4) Description of the special handling of UTRA UE Radio Capability information is added. | | | | | | | | |
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| ***Consequences if not approved:*** | | 1) Risk that a UE does not indicate a change of its E-UTRA Radio Capability information relevant for E-UTRA connected to EPC to the network and that therefore a subsequent inter-system handover to EPS, e.g. for an EPS fallback call, fails.  2) Risk that a UE triggers a "UE Radio Capability Update" each time it returns to NG-RAN after SRVCC handover to UTRA. This can create considerable, unnecessary signalling, as the NG-RAN will always request the NR and E­UTRA UE Radio Capability information. | | | | | | | | |
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| ***Clauses affected:*** | | 5.3.3.2.5, 5.4.4.1 | | | | | | | | |
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|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
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| ***This CR's revision history:*** | |  | | | | | | | | |

\*\*\*\*\* First change \*\*\*\*\*

##### 5.3.3.2.5 CM-CONNECTED with RRC Inactive state

RRC Inactive state applies to NG-RAN. UE support for RRC Inactive state is defined in TS 38.306 [69] for NR and TS 36.306 [70] for E-UTRA connected to 5GC. RRC Inactive is not supported by NB-IoT connected to 5GC.

The AMF shall provide assistance information to the NG-RAN, to assist the NG-RAN's decision whether the UE can be sent to RRC Inactive state except due to some exceptional cases such as:

- PLMN (or AMF set) does not support RRC Inactive;

- The UE needs to be kept in CM-CONNECTED State (e.g. for tracking).

The "RRC Inactive Assistance Information" includes:

- UE specific DRX values;

- UE specific extended idle mode DRX values (cycle length and Paging Time Window length);

- The Registration Area provided to the UE;

- Periodic Registration Update timer;

- If the AMF has enabled MICO mode for the UE, an indication that the UE is in MICO mode;

- Information from the UE identifier, as defined in TS 38.304 [50] for NR and TS 36.304 [52] for E-UTRA connected to 5GC, that allows the RAN to calculate the UE's RAN paging occasions.

The RRC Inactive Assistance Information mentioned above is provided by the AMF during N2 activation with the (new) serving NG-RAN node (i.e. during Registration, Service Request, Handover) to assist the NG RAN's decision whether the UE can be sent to RRC Inactive state. If the AMF allocates a new Registration Area to the UE, the AMF should update the NG-RAN with the new Registration Area by sending the RRC Inactive Assistance Information accordingly.

RRC Inactive state is part of RRC state machine, and it is up to the RAN to determine the conditions to enter RRC Inactive state. If any of the parameters included in the RRC Inactive Assistance Information changes as the result of NAS procedure, the AMF shall update the RRC Inactive Assistance Information to the NG-RAN node.

When the UE is in CM-CONNECTED state, if the AMF has provided RRC Inactive assistance information, the RAN node may decide to move a UE to CM-CONNECTED with RRC Inactive state.

The state and "endpoints" (in the case of Dual Connectivity configuration) of the N2 and N3 reference points are not changed by the UE entering CM-CONNECTED with RRC Inactive state. A UE in RRC inactive state is aware of the RAN Notification area and periodic RAN Notification Area Update timer.

The 5GC network is not aware of the UE transitions between CM-CONNECTED with RRC Connected and CM-CONNECTED with RRC Inactive state, unless the 5GC network is notified via N2 notification procedure in TS 23.502 [3] clause 4.8.3.

At transition into CM-CONNECTED with RRC Inactive state, the NG-RAN configures the UE with a periodic RAN Notification Area Update timer taking into account the value of the Periodic Registration Update timer value indicated in the RRC Inactive Assistance Information, and uses a guard timer with a value longer than the RAN Notification Area Update timer value provided to the UE.

If the periodic RAN Notification Area Update guard timer expires in NG-RAN, the NG-RAN shall initiate AN Release procedure as specified in TS 23.502 [3], clause 4.2.6.

When the UE is in CM-CONNECTED with RRC Inactive state, the UE performs PLMN selection procedures as defined in TS 23.122 [17] and TS 24.501 [47].

When the UE is CM-CONNECTED with RRC Inactive state, the UE may resume the RRC Connection due to:

- Uplink data pending;

- Mobile initiated NAS signalling procedure;

- As a response to RAN paging;

- Notifying the network that it has left the RAN Notification Area;

- Upon periodic RAN Notification Area Update timer expiration.

If the UE resumes the connection in a different NG-RAN node within the same PLMN or equivalent PLMN, the UE AS context is retrieved from the old NG-RAN node and a procedure is triggered towards the CN (see TS 23.502 [3], clause 4.8.2).

NOTE 1: With Dual Connectivity configuration if the UE resumes the RRC connection in the Master RAN node, the Secondary RAN node configuration is defined in TS 38.300 [27].

If the RAN paging procedure, as defined in TS 38.300 [27], is not successful in establishing contact with the UE the procedure shall be handled by the network as follows:

- If NG-RAN has at least one pending NAS PDU for transmission, the RAN node shall initiate the AN Release procedure (see TS 23.502 [3], clause 4.2.6,) to move the UE CM state in the AMF to CM-IDLE state and indicate to the AMF the NAS non-delivery.

- If NG RAN has only pending user plane data for transmission, the NG-RAN node may keep the N2 connection active or initiate the AN Release procedure (see TS 23.502 [3], clause 4.2.6) based on local configuration in NG-RAN.

NOTE 2: The user plane data which triggers the RAN paging can be lost, e.g. in the case of RAN paging failure.

If a UE in CM-CONNECTED with RRC Inactive state performs cell selection to GERAN/UTRAN/E-UTRAN, it shall follow idle mode procedures of the selected RAT as specified in clause 5.17.

In addition, a UE in CM-CONNECTED state with RRC Inactive state shall enter CM-IDLE state and initiates the NAS signalling recovery (see TS 24.501 [47]) in the following cases:

- If RRC resume procedure fails,

If the UE receives Core Network paging,

- If the periodic RAN Notification Area Update timer expires and the UE cannot successfully resume the RRC Connection,

- In any other failure scenario that cannot be resolved in RRC Inactive state and requires the UE to move to CM-IDLE state.

When a UE is in CM-CONNECTED with RRC Inactive state, and a trigger to change the UE's NG-RAN or E‑UTRAN UE Radio Capability information happens, the UE shall move to CM-IDLE state and initiate the procedure for updating UE Radio Capability defined in clause 5.4.4.1. (For specific requirements for a UE operating in dual-registration mode see clause 5.17.2.1.)

When UE is in CM-CONNECTED with RRC Inactive state, if RAN has received Location Reporting Control message from AMF with the Reporting Type indicating single stand-alone report, the RAN shall perform RAN paging before reporting the location to AMF.

When UE is in CM-CONNECTED with RRC Inactive state, if RAN has received Location Reporting Control message from AMF with the Reporting Type indicating continuously reporting whenever the UE changes cell, the RAN shall send a Location Report message to AMF including UE's last known location with time stamp.

When the UE is CM-CONNECTED with RRC Inactive state. If the AMF receives Nudm\_UECM\_DeregistrationNotification from UDM, the AMF shall initiate AN Release procedure as specified in TS 23.502 [3], clause 4.2.6.

When UE is in CM-CONNECTED with RRC Inactive state, if RAN has received Location Reporting Control message from AMF with the Reporting Type of the Area Of Interest based reporting, the RAN shall send a Location Report message to AMF including UE presence in the Area Of Interest (i.e., IN, OUT, or UNKNOWN) and the UE's last known location with time stamp.

When the UE is in CM-CONNECTED with RRC Inactive state, if the old NG-RAN node that sents the UE into RRC Inactive state receives the downlink N2 signalling, it initiates the RAN paging as defined in TS 38.300 [27]. If the UE resumes the RRC Connection towards a different NG-RAN node, the old NG-RAN node includes the "UE Context Transfer" indication into a response container to the NF (e.g. AMF or SMF) that generates such N2 downlink signalling. Then the NF shall reattempt the same procedure when the path switch from the old NG-RAN node to the new NG-RAN node is complete.

\*\*\*\*\* Next change \*\*\*\*\*

#### 5.4.4.1 UE radio capability information storage in the AMF

This clause applies when no radio capability signalling optimisation is used between a UE and the network.

The UE Radio Capability information contains information on RATs that the UE supports (e.g. power class, frequency bands, etc). Consequently, this information can be sufficiently large that it is undesirable to send it across the radio interface at every transition of UE CM state in the AMF from CM‑IDLE to CM‑CONNECTED. To avoid this radio overhead, the AMF shall store the UE Capability information during CM‑IDLE state for the UE and RM-REGISTERED state for the UE and the AMF shall if it is available, send its most up to date UE Radio Capability information to the RAN in the N2 REQUEST message, i.e. INITIAL CONTEXT SETUP REQUEST or UE RADIO CAPABILITY CHECK REQUEST.

NOTE 1: Due to issues with the handling of dynamic UMTS security parameters, the UTRA UE Radio Capability information is excluded from the information stored in the AMF (see 3GPP TS 38.300 [27]).

The AMF deletes the UE radio capability when the UE RM state in the AMF transitions to RM-DEREGISTERED.

The UE Radio Capability is maintained in the core network, even during AMF reselection.

NOTE 2: The UE Radio Capability is not transferred to EPC during the inter-system mobility.

If the UE's NG-RAN or E‑UTRAN UE Radio Capability information changes while in CM-IDLE state, the UE shall perform the Registration procedure with the Registration type set to Mobility Registration Update and it also includes "UE Radio Capability Update". (For specific requirements for a UE operating in dual-registration mode see clause 5.17.2.1.) When the AMF receives Mobility Registration Update Request with "UE Radio Capability Update" requested by the UE, it shall delete any UE Radio Capability information that it has stored for the UE.

If the trigger to change the UE's NG-RAN or E‑UTRAN UE Radio Capability information happens when the UE is in CM-CONNECTED state, the UE shall first enter CM-IDLE state and then perform the Registration procedure with the Registration type set to Mobility Registration Update and it also includes "UE Radio Capability Update". (For specific requirements for a UE operating in dual-registration mode see clause 5.17.2.1.)

The RAN stores the UE Radio Capability information, received in the N2 message or obtained from the UE, for the duration of the UE staying in RRC connected or RRC Inactive state. Before any 5G SRVCC handover attempt from NG-RAN to UTRAN, the RAN retrieves the UE's UTRA UE Radio Capabilities from the UE.

NOTE 3: Due to issues with dynamic UTRAN security parameters, special rules apply to the handling of the UE's UTRA UE Radio Capability information at 5G SRVCC handover to UTRAN (see e.g. the HandoverPreparationInformation message description in 3GPP TS 36.331 [51] and 3GPP TS 38.331 [28]).

If the AMF sends N2 REQUEST (i.e. INITIAL CONTEXT SETUP REQUEST or UE RADIO CAPABILITY CHECK REQUEST) message to NG-RAN without UE Radio Capability information in that message and there is no UE Radio Capability information available in RAN, this triggers the RAN to request the UE Radio Capability from the UE and to upload it to the AMF in the N2 UE RADIO CAPABILITY INFO INDICATION message.

If a UE supports both NB-IoT and other RATs the UE handles the UE Radio capability information as follows:

- When the UE is camping on NB-IoT the UE provides only NB-IoT UE radio capabilities to the network.

- When the UE is not camping on NB-IoT, the UE provides UE radio capabilities for the RAT but not NB-IoT UE radio capabilities to the network.

In order to handle the distinct UE radio capabilities, the AMF stores a separate NB-IoT specific UE Radio Capability information when the UE provides the UE Radio Capability information while camping on NB-IoT.

When the UE is camping on NB-IoT, the AMF sends, if available, the NB-IoT RAT specific UE Radio Capability information to the E-UTRAN.

When the UE is not camping on NB-IoT, the AMF sends, if available, UE radio capabilities for the RAT but not NB-IoT radio capabilities.

\*\*\*\*\* End of change \*\*\*\*\*