**3GPP TSG-RAN WG2 Meeting #117 electronic R2-22**

**Electronic Meeting, Feb 21– Mar 03, 2022**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
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|  | **36.321** | **CR** | **draft** | **rev** | **-** | **Current version:** | **16.6.0** |  |
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| *For* [***HE******LP***](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 |  | Radio Access Network | **X** | Core Network |  |

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| ***Title:***  | Solution for random access issue on multiCarrier in NB-IoT |
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| ***Source to WG:*** | CMCC |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NB\_IOTenh3-Core |  | ***Date:*** | 2022-02-21 |
|  |  |  |  |  |
| ***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 canbe 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:*** | In real NB-IoT network, single-carrier cells are deployed to meet coverage requirements for most scenarios, and multi-carriers cells are deployed for concurrent service scenarios to meet capacity expansion requirements. The anchor carriers are deployed with inter frequency to reduce interference among cells, and it’s generally that the non-anchor carriers in one cell are deployed on the same frequency as the anchor carrier in the neighbour cells. The downlink narrowband reference-signal EPRE (Energy Per Resource Element) of the non-anchor carriers is generally lower relative to the downlink narrowband reference-signal EPRE of the anchor carrier to reduce the interference between the non-anchor carrier and the neighbour cells using the same frequency. Due to lower EPRE of non-anchor carrier than EPRE of anchor carrier, coverage of non-anchor carrier is shrunken than the anchor carrier. Non-anchor carrier suffered more UL interference from the same frequency neighborhood cell with uplink service terminals. This may degrade uplink performance. According to the actual coverage, there is the overlapping area that the UE’s CE levels is different between on the anchor carrier and non-anchor carriers, and CE level on the non-anchor carriers is usually worse than the CE level for the anchor carrier. The UE may fail to access to the non-anchor carrier or try more times to access to the non-anchor carrier with the nprach resource based on the anchor carrier’s CE level.  |
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| ***Summary of change:*** | Modify the 5.1.1 and 5.1.2 to introduce a new RSRP Threshold list for each non-anchor carrier and if the UE selects a non-anchor carrier and the CE level of the non-anchor carrier is worse than that of the anchor carrier, the UE will access to the anchor carrier.**Impact analysis**Impacted functionality:Random AccessInter-operability:1. If the UE selects a non-anchor carrier and the CE level of the non-anchor carrier is worse than that of the anchor carrier, the UE will access to the anchor carrier.
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| ***Consequences if not approved:*** | Due to lower EPRE of non-anchor carrier than EPRE of anchor carrier, shrunken coverage of non-anchor carrier may result in MSG2 failure if same *npdcch-NumRepetitions-RA-r14* is configured for anchor carrier and non-anchor carrier. Non-anchor carrier is suffered more UL interference from the same frequency neighbor cell with uplink service terminals. This may degrade uplink performance, e.g., MSG 1 failure on non-anchor carrier. |
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| ***Clauses affected:*** | 5.1.1 and 5.1.2 |
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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:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

*Start of Change*

### 5.1.1 Random Access Procedure initialization

/\*Partially omitted\*/

The Random Access procedure described in this clause is initiated by a PDCCH order, by the MAC sublayer itself or by the RRC sublayer. Random Access procedure on an SCell shall only be initiated by a PDCCH order. If a MAC entity receives a PDCCH transmission consistent with a PDCCH order, as specified inTS 36.212 [5], masked with its C-RNTI, and for a specific Serving Cell, the MAC entity shall initiate a Random Access procedure on this Serving Cell. For Random Access on the SpCell a PDCCH order or RRC optionally indicate the *ra-PreambleIndex* and the *ra-PRACH-MaskIndex*, except for NB-IoT where the subcarrier index is indicated;and for Random Access on an SCell, the PDCCH order indicates the *ra-PreambleIndex* with a value different from 000000 and the *ra-PRACH-MaskIndex*. For the pTAG preamble transmission on PRACH and reception of a PDCCH order are only supported for SpCell. If the UE is an NB-IoT UE, the Random Access procedure is performed on the anchor carrier or one of the non-anchor carriers for which PRACH resource has been configured in system information.

Before the procedure can be initiated, the following information for related Serving Cell is assumed to be available for UEs other than NB-IoT UEs, BL UEs or UEs in enhanced coverage, as specified in TS 36.331 [8], unless explicitly stated otherwise:

- the available set of PRACH resources for the transmission of the Random Access Preamble, *prach-ConfigIndex*.

- the groups of Random Access Preambles and the set of available Random Access Preambles in each group (SpCell only):

 The preambles that are contained in Random Access Preambles group A and Random Access Preambles group B are calculated from the parameters *numberOfRA-Preambles* and *sizeOfRA-PreamblesGroupA*:

 If *sizeOfRA-PreamblesGroupA* is equal to *numberOfRA-Preambles* then there is no Random Access Preambles group B. The preambles in Random Access Preamble group A are the preambles 0 to *sizeOfRA-PreamblesGroupA* – 1 and, if it exists, the preambles in Random Access Preamble group B are the preambles *sizeOfRA-PreamblesGroupA* to *numberOfRA-Preambles* – 1 from the set of 64 preambles as defined in TS 36.211 [7].

- if Random Access Preambles group B exists, the thresholds, *messagePowerOffsetGroupB* and *messageSizeGroupA*, the configured UE transmitted power of the Serving Cell performing the Random Access Procedure, PCMAX, c, as specified in TS 36.101 [10], and the offset between the preamble and Msg3, *deltaPreambleMsg3*, that are required for selecting one of the two groups of Random Access Preambles (SpCell only).

- the RA response window size *ra-ResponseWindowSize*.

- the power-ramping factor *powerRampingStep*.

- the maximum number of preamble transmission *preambleTransMax*.

- the initial preamble power *preambleInitialReceivedTargetPower*.

- the preamble format based offset DELTA\_PREAMBLE (see clause 7.6).

- the maximum number of Msg3 HARQ transmissions *maxHARQ-Msg3Tx* (SpCell only).

- the Contention Resolution Timer *mac-ContentionResolutionTimer* (SpCell only).

NOTE 1: The above parameters may be updated from upper layers before each Random Access procedure is initiated.

The following information for related Serving Cell is assumed to be available before the procedure can be initiated for NB-IoT UEs, BL UEs or UEs in enhanced coverage, as specified in TS 36.331 [8]:

- if the UE is a BL UE or a UE in enhanced coverage:

- the available set of PRACH resources associated with each enhanced coverage level supported in the Serving Cell for the transmission of the Random Access Preamble, *prach-ConfigIndex*.

- for EDT, the available set of PRACH resources associated with EDT for each enhanced coverage level supported in the Serving Cell for the transmission of the Random Access Preamble, *prach-ConfigIndex*.

- the groups of Random Access Preambles and the set of available Random Access Preambles in each group(SpCell only):

- except for EDT:

- if *sizeOfRA-PreamblesGroupA* is not equal to *numberOfRA-Preambles*:

- Random Access Preambles group A and B exist and are calculated as above;

- else:

- the preambles that are contained in Random Access Preamble groups for each enhanced coverage level, if it exists, are the preambles *firstPreamble* to *lastPreamble*.

- for EDT, the preambles that are contained in Random Access Preamble groups for each enhanced coverage level, if it exists, are the preambles *firstPreamble* to *edt-LastPreamble* if PRACH resources configured by *edt-PRACH-ParametersCE* are different from the PRACH resources configured by *PRACH-ParametersCE* for all enhanced coverage levels and *edt-PRACH-ParametersCE* for all other enhanced coverage levels, otherwise the preambles for EDT are the preambles *lastPreamble*+1 to *edt-LastPreamble*.

NOTE 2: When a PRACH resource is shared for multiple enhanced coverage levels, and enhanced coverage levels are differentiated by different preamble indices, Group A and Group B is not used for this PRACH resource.

- if the UE is an NB-IoT UE:

- the available set of PRACH resources supported in the Serving Cell on the anchor carrier, *nprach-ParametersList*, and on the non-anchor carriers, in *ul-ConfigList*.

- for EDT, the available set of PRACH resources associated with EDT on anchor carrier, *nprach-ParametersList-EDT*, and on the non-anchor carriers, in *ul-ConfigList*.

- for random access resource selection and preamble transmission:

- a PRACH resource is mapped into an enhanced coverage level.

- each PRACH resource contains a set of *nprach-NumSubcarriers* subcarriers which can be partitioned into one or two groups for single/multi-tone Msg3 transmission by *nprach-SubcarrierMSG3-RangeStart* and *nprach-NumCBRA-StartSubcarriers* as specified in TS 36.211 [7], clause 10.1.6.1. Each group is referred to as a Random Access Preamble group below in the procedure text.

- a subcarrier is identified by the subcarrier index in the range:
[*nprach-SubcarrierOffset*, *nprach-SubcarrierOffset* + *nprach-NumSubcarriers* -1]

- each subcarrier of a Random Access Preamble group corresponds to a Random Access Preamble.

- when the subcarrier index is explicitly sent from the eNB as part of a PDCCH order *ra-PreambleIndex* shall be set to the signalled subcarrier index.

- the mapping of the PRACH resources into enhanced coverage levels is determined according to the following:

- the number of enhanced coverage levels is equal to one plus the number of RSRP thresholds present in *rsrp-ThresholdsPrachInfoList.*

- the number of enhanced coverage levels *for each non-Anchor* is equal to one plus the number of RSRP thresholds present in *rsrp-ThresholdsPrachNonAnchorInfoList.*

- each enhanced coverage level has one anchor carrier PRACH resource present in *nprach-ParametersList* and zero or one PRACH resource for each non-anchor carrier signalled in *ul-ConfigList*.

- for EDT, each enhanced coverage level has zero or one anchor carrier PRACH resource present in *nprach-ParametersList-EDT* and zero or one PRACH resource for each non-anchor carrier signalled in *ul-ConfigList*.

- enhanced coverage levels are numbered from 0 and the mapping of PRACH resources to enhanced coverage levels are done in increasing *numRepetitionsPerPreambleAttempt* order.

- when multiple carriers provide PRACH resources for the same enhanced coverage level, the UE will randomly select one of them using the following selection probabilities:

- the selection probability of the anchor carrier PRACH resource for the given enhanced coverage level, *nprach-ProbabilityAnchor*, is given by the corresponding entry in *nprach-ProbabilityAnchorList*

- the selection probability is equal for all non-anchor carrier PRACH resources and the probability of selecting one PRACH resource on a given non-anchor carrier is (1- *nprach-ProbabilityAnchor*)/(number of non-anchor NPRACH resources)

- the criteria to select PRACH resources based on RSRP measurement per enhanced coverage level supported in the Serving Cell *rsrp-ThresholdsPrachInfoList*.

- the criteria to select PRACH resources for the non-anchor carrier based on RSRP measured on the non-anchor carrier per enhanced coverage level supported in the Serving Cell *rsrp-ThresholdsPrachNonAnchorInfoList.*

- the maximum number of preamble transmission attempts per enhanced coverage level supported in the Serving Cell *maxNumPreambleAttemptCE*.

- the number of repetitions required for preamble transmission per attempt for each enhanced coverage level supported in the Serving Cell *numRepetitionPerPreambleAttempt*.

- the configured UE transmitted power of the Serving Cell performing the Random Access Procedure, PCMAX, c, as specified in TS 36.101 [10].

- the RA response window size *ra-ResponseWindowSize* and the Contention Resolution Timer *mac-ContentionResolutionTimer* (SpCell only) per enhanced coverage level supported in the Serving Cell.

- for EDT, the Contention Resolution Timer *mac-ContentionResolutionTimer* configured for EDT (SpCell only) per enhanced coverage level supported in the Serving Cell.

- the power-ramping factor *powerRampingStep* and optionally *powerRampingStepCE1*.

- the maximum number of preamble transmission *preambleTransMax-CE*.

- the initial preamble power *preambleInitialReceivedTargetPower* and optionally *preambleInitialReceivedTargetPowerCE1*.

- the preamble format based offset DELTA\_PREAMBLE (see clause 7.6).

- for NB-IoT, the use of contention free random access *ra-CFRA-Config*.

The Random Access procedure shall be performed as follows:

- flush the Msg3 buffer;

- set the PREAMBLE\_TRANSMISSION\_COUNTER to 1;

- if the UE is an NB-IoT UE, a BL UE or a UE in enhanced coverage:

- set the PREAMBLE\_TRANSMISSION\_COUNTER\_CE to 1;

- if the starting enhanced coverage level, or for NB-IoT the starting number of NPRACH repetitions, has been indicated in the PDCCH order which initiated the Random Access procedure, or if the starting enhanced coverage level has been provided by upper layers:

- the MAC entity considers itself to be in that enhanced coverage level regardless of the measured RSRP;

- else:

- if the RSRP threshold of enhanced coverage level 3 is configured by upper layers in *rsrp-ThresholdsPrachInfoList* and the measured RSRP is less than the RSRP threshold of enhanced coverage level 3 and the UE is capable of enhanced coverage level 3 then:

- the MAC entity considers to be in enhanced coverage level 3;

- else if the RSRP threshold of enhanced coverage level 2 configured by upper layers in *rsrp-ThresholdsPrachInfoList* ,and the measured RSRP is less than the RSRP threshold of enhanced coverage level 2 and the UE is capable of enhanced coverage level 2 then:

- the MAC entity considers to be in enhanced coverage level 2;

- else if the measured RSRP is less than the RSRP threshold of enhanced coverage level 1 as configured by upper layers in *rsrp-ThresholdsPrachInfoList* , then:

- the MAC entity considers to be in enhanced coverage level 1;

- else:

- the MAC entity considers to be in enhanced coverage level 0;

- if *rsrp-ThresholdsPrachNonAnchorInfoList* is configured:

- if theRSRP threshold of enhanced coverage level 3 is configured by upper layers in *rsrp-ThresholdsPrachNonAnchorInfoList* for the non-anchor carriers*,* and themeasured RSRP for the non-anchor carrier isless than theRSRP threshold of enhanced coverage level 3 and the UE is capable of enhanced coverage level 3 then:

- the MAC entity considers to be in enhanced coverage level 3 for non-anchor carrier;

- else if the RSRP threshold of enhanced coverage level 2 configured by upper layers in *rsrp-ThresholdsPrachNonAnchorInfoList* for the non-anchor carrier,and the measured RSRP for the non-anchor carrier is less than the RSRP threshold of enhanced coverage level 2 and the UE is capable of enhanced coverage level 2 then:

- the MAC entity considers to be in enhanced coverage level 2 for non-anchor carrier;

- else ifthe measured RSRP isless than theRSRP threshold of enhanced coverage level 1 as configured by upper layersin *rsrp-ThresholdsPrachNonAnchorInfoList* for the non-anchor carrier, then:

- the MAC entity considers to be in enhanced coverage level 1 for non-anchor carrier;

- else:

- the MAC entity considers to be in enhanced coverage level 0 for non-anchor carrier;

- set the backoff parameter value to 0 ms;

- for the RN, suspend any RN subframe configuration;

- proceed to the selection of the Random Access Resource (see clause 5.1.2).

NOTE 3: There is only one Random Access procedure ongoing at any point in time in a MAC entity. If the MAC entity receives a request for a new Random Access procedure while another is already ongoing in the MAC entity, it is up to UE implementation whether to continue with the ongoing procedure or start with the new procedure.

NOTE 4: An NB-IoT UE measures RSRP on the anchor carrier and the non-anchor carriers.

### 5.1.2 Random Access Resource selection

The Random Access Resource selection procedure shall be performed as follows:

- for BL UEs or UEs in enhanced coverage or NB-IoT UEs, if EDT is initiated by the upper layers:

- if the message size (UL data available for transmission plus MAC header and, where required, MAC control elements) is larger than the TB size signalled in *edt-TBS* for the selected enhanced coverage level for EDT; or

- if the PRACH resource associated with EDT for the selected enhanced coverage level is not available:

- indicate to upper layers that EDT is cancelled;

- for BL UEs or UEs in enhanced coverage, select the PRACH resource set corresponding to the selected enhanced coverage level. For EDT, the PRACH resource set shall correspond to the set associated with EDT for the selected enhanced coverage level.

- if, except for NB-IoT, *ra-PreambleIndex* (Random Access Preamble) and *ra-PRACH-MaskIndex* (PRACH Mask Index) have been explicitly signalled and *ra-PreambleIndex* is not 000000:

- the Random Access Preamble and the PRACH Mask Index are those explicitly signalled;

- else if, for NB-IoT, *ra-PreambleIndex* (Random Access Preamble) and PRACH resource have been explicitly signalled:

- the PRACH resource is that explicitly signalled;

- if the *ra-PreambleIndex* signalled is not 000000:

- if *ra-CFRA-Config* is configured:

- the Random Access Preamble is set to *nprach-SubcarrierOffset* + *nprach-NumCBRA-StartSubcarriers* + (*ra-PreambleIndex* modulo (*nprach-NumSubcarriers* - *nprach-NumCBRA-StartSubcarriers*)), where *nprach-SubcarrierOffset*, *nprach-NumCBRA-StartSubcarriers* and *nprach-NumSubcarriers* are parameters in the currently used PRACH resource.

- else:

- the Random Access Preamble is set to *nprach-SubcarrierOffset* + (*ra-PreambleIndex* modulo *nprach-NumSubcarriers*), where *nprach-SubcarrierOffset* and *nprach-NumSubcarriers* are parameters in the currently used PRACH resource.

- else:

- select the Random Access Preamble group according to the PRACH resource and the support for multi-tone Msg3 transmission. A UE supporting multi-tone Msg3 shall only select the single-tone Msg3 Random Access Preambles group if there is no multi-tone Msg3 Random Access Preambles group.

- randomly select a Random Access Preamble within the selected group.

- else the Random Access Preamble shall be selected by the MAC entity as follows:

- if the UE is a BL UE or UE in enhanced coverage and EDT is initiated:

- select the Random Access Preambles group corresponding to PRACH resource for EDT for the selected enhanced coverage level.

- else if the UE is a BL UE or UE in enhanced coverage and Random Access Preamble group B does not exist:

- select the Random Access Preambles group corresponding to the selected enhanced coverage level.

- else if the UE is an NB-IoT UE:

- randomly select one of the PRACH resources corresponding to the selected enhanced coverage level according to the configured probability distribution, and select the Random Access Preambles group corresponding to the PRACH resource and the support for multi-tone Msg3 transmission. A UE supporting multi-tone Msg3 shall only select the single-tone Msg3 Random Access Preambles group if there is no multi-tone Msg3 Random Access Preambles group. For EDT, the PRACH resource shall correspond to resource associated with EDT for the selected enhanced coverage level.

- If *rsrp-ThresholdsPrachNonAnchorInfoList* is configured, randomly select one of the PRACH resources corresponding to the selected enhanced coverage level according to the configured probability distribution, and if the UE selects a non-anchor carrier, the CE level of the users on the non-anchor carrier is determined based on comparison between NRSRP measurement results and the RSRP threshold for the non-anchor carrier. The NRSRP measurement results are measured by the UE on this non-anchor carrier.

- If the CE level of the non-anchor carrier is worse than that of the anchor carrier,

 - the UE will access to the anchor carrier with the CE level determined by the anchor carrier.

- else:

- the UE will access to the non-anchor carrier with the CE level determined by the anchor carrier.

- else if Msg3 has not yet been transmitted, the MAC entity shall:

- if Random Access Preambles group B exists and any of the following events occur:

- the potential message size (UL data available for transmission plus MAC header and, where required, MAC control elements) is greater than *messageSizeGroupA* and the pathloss is less than PCMAX,c (of the Serving Cell performing the Random Access Procedure) – *preambleInitialReceivedTargetPower* – *deltaPreambleMsg3* – *messagePowerOffsetGroupB*;

- the Random Access procedure was initiated for the CCCH logical channel and the CCCH SDU size plus MAC header is greater than *messageSizeGroupA*;

- select the Random Access Preambles group B;

- else:

- select the Random Access Preambles group A.

- else, if Msg3 is being retransmitted, the MAC entity shall:

- select the same group of Random Access Preambles as was used for the preamble transmission attempt corresponding to the first transmission of Msg3.

- randomly select a Random Access Preamble within the selected group. The random function shall be such that each of the allowed selections can be chosen with equal probability;

- except for NB-IoT, set PRACH Mask Index to 0.

- determine the next available subframe containing PRACH permitted by the restrictions given by the *prach-ConfigIndex* (except for NB-IoT)*,* the PRACH Mask Index (except for NB-IoT, see clause 7.3), physical layer timing requirements, as specified in TS 36.213 [2], and in case of NB-IoT, the subframes occupied by PRACH resources related to a higher enhanced coverage level (a MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH subframe);

- except for NB-IoT:

- if the transmission mode is TDD and the PRACH Mask Index is equal to zero:

- if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

- randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe.

- else:

- randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe and the next two consecutive subframes.

- else:

- determine a PRACH within the determined subframe in accordance with the requirements of the PRACH Mask Index, if any.

- for NB-IoT UEs, BL UEs or UEs in enhanced coverage, select the *ra-ResponseWindowSize* and *mac-ContentionResolutionTimer* corresponding to the selected enhanced coverage level and PRACH.

- proceed to the transmission of the Random Access Preamble (see clause 5.1.3).

*End of Change*