**3GPP TSG-WG2 Meeting #111-e *R2-2007567***

**17 – 28 August 2020**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
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|  | **36.304** | **CR** | **0810** | **rev** | **1** | **Current version:** | **16.1.0** |  |
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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 | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:***  | Group WUS corrections |
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| ***Source to WG:*** | Qualcomm Incorporated, Nokia, Nokia Shanghai Bell, ZTE Corporation, Sanechips, Huawei, HiSilicon |
| ***Source to TSG:*** | R2  |
|  |  |
| ***Work item code:*** | LTE\_eMTC5-Core, NB\_IOTenh3-Core |  | ***Date:*** | 2020-08-18 |
|  |  |  |  |  |
| ***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-12 (Release 12)**Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
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| ***Reason for change:*** | For the explanation of total weight W, only GWUS configuration is considered (e.g. UE GWUS capability is missing). In fact, UE not supporting GWUS, the W should be total weight of all NB-IoT paging carriers.For GWUS alternation “div(x)” is used to indicate the maximal integer value less than or equal to x, which has multiple mathematical meaning (e.g. floor(), or divergence()), and is seldomly used in 3GPP. Instead, floor(x) is usually used to indicate the maximal integer value less than or equal to x in 3GPP. Furtheremore, div usage in the equeation is wrong, normaly it is ‘a div b’ and not ‘div(a/b)’.Indentation of bullets not correct hence can cause confusion to the reader.Group WUS is only applicable in RRC\_IDLE but this is not clear from the current specification.Recursive use of variable maxWG in summation and this is wrong.Mixture of ‘WUS Resource’ and ‘WUS resource’ used in the specification and such this is unnecessary.  |
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| ***Summary of change:*** | Clairfy that ‘Total weight of all NB-IoT paging carriers configured with GWUS’ is only applicable to UE supporting GWUS.Add condition that UE has to be in RRC\_IDLE to use GWUS.Correct equation to count the WUS groups configured for a gap.Change equation for GWUS alternbation to use FLOOR function instead of div.Change ‘time offset’ to ‘timeoffset’ to be consistent with legacy text.Remove unnecessary intermediate variable.Change ‘WUS Resource’ to ‘WUS resource’. Change WG to WG’ to make it easier to distinguish from wg.Clean-up bullet text layout.**Impact analysis**Impacted functionality:Group WUSInter-operability:If the network is implemented according to the CR but UE is not, no interoperability problems are foreseen.If the UE is implemented according to the CR but UE is not, no interoperability problems are foreseen. |
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| ***Consequences if not approved:*** | Description of group WUS remains unclear. |
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| ***Clauses affected:*** | 7.1, 7.5.1, 7.5.2, 7.5.3, 7.5.4, 7.5.5 |
|  |  |
|  | **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 ...  |
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| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

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| Start of first change |

7.1 Discontinuous Reception for paging

The UE may use Discontinuous Reception (DRX) in idle mode in order to reduce power consumption. One Paging Occasion (PO) is a subframe where there may be P-RNTI transmitted on PDCCH or MPDCCH or, for NB-IoT on NPDCCH addressing the paging message. In P-RNTI transmitted on MPDCCH case, PO refers to the starting subframe of MPDCCH repetitions. In case of P-RNTI transmitted on NPDCCH, PO refers to the starting subframe of NPDCCH repetitions unless subframe determined by PO is not a valid NB-IoT downlink subframe then the first valid NB-IoT downlink subframe after PO is the starting subframe of the NPDCCH repetitions. The paging message is same for both RAN initiated paging and CN initiated paging.

The UE initiates RRC Connection Resume procedure upon receiving RAN paging. If the UE receives a CN initiated paging in RRC\_INACTIVE state, the UE moves to RRC\_IDLE and informs NAS.

One Paging Frame (PF) is one Radio Frame, which may contain one or multiple Paging Occasion(s). When DRX is used the UE needs only to monitor one PO per DRX cycle.

One Paging Narrowband (PNB) is one narrowband, on which the UE performs the paging message reception.

PF, PO, and PNB are determined by following formulae using the DRX parameters provided in System Information:

PF is given by following equation:

SFN mod T= (T div N)\*(UE\_ID mod N)

Index i\_s pointing to PO from subframe pattern defined in 7.2 will be derived from following calculation:

i\_s = floor(UE\_ID/N) mod Ns

If P-RNTI is monitored on MPDCCH, the PNB is determined by the following equation:

PNB = floor(UE\_ID/(N\*Ns)) mod Nn

If P-RNTI is monitored on NPDCCH and the UE supports paging on a non-anchor carrier, and if paging configuration for non-anchor carrier is provided in system information, then the paging carrier is determined by the paging carrier with smallest index n (0 ≤ n ≤ Nn-1) fulfilling the following equation:

floor(UE\_ID/(N\*Ns)) mod W < W(0) + W(1) + … + W(n)

System Information DRX parameters stored in the UE shall be updated locally in the UE whenever the DRX parameter values are changed in SI. If the UE has no IMSI, for instance when making an emergency call without USIM, the UE shall use as default identity UE\_ID = 0 in the PF, i\_s, and PNB formulas above. If the UE has no 5G-S-TMSI, for instance when the UE has not yet registered onto the network, the UE shall use as default identity UE\_ID = 0 in the PF and i\_s formulas above.

The following Parameters are used for the calculation of the PF, i\_s, PNB, and the NB-IoT paging carrier:

- T: DRX cycle of the UE.

 Except for NB-IoT: If a UE specific extended DRX value of 512 radio frames is configured by upper layers according to 7.3, T =512. Otherwise, T is determined by the shortest of the UE specific DRX value, if allocated by upper layers, and a default DRX value broadcast in system information. If UE specific DRX is not configured by upper layers, the default value is applied. UE specific DRX is not applicable for NB-IoT. In RRC\_INACTIVE state, if extended DRX is not configured by upper layers as defined in 7.3, T is determined by the shortest of the RAN paging cycle, the UE specific paging cycle, and the default paging cycle, if allocated by upper layers. Otherwise, in RRC\_INACTIVE state when extended DRX is configured by upper layers, T is determined by the shortest of the RAN paging cycle, the UE specific paging cycle, if allocated by upper layers and the default paging cycle during the PTW as defined in 7.3, and by the RAN paging cycle outside the PTW.

 For NB-IoT: If UE specific DRX value is allocated by upper layers and minimum UE specific DRX value is broadcast in system information, T = min (default DRX value, max (UE specific DRX value, minimum UE specific DRX value broadcast in system information)). If UE specific DRX is not configured by upper layers or if the minimum UE specific DRX value is not broadcast in system information, the default DRX value is applied.

- nB: 4T, 2T, T, T/2, T/4, T/8, T/16, T/32, T/64, T/128, and T/256, and for NB-IoT also T/512, and T/1024.

- N: min(T,nB)

- Ns: max(1,nB/T)

- Nn: number of paging narrowbands (for P-RNTI monitored on MPDCCH) or paging carriers (for P-RNTI monitored on NPDCCH) determined as follows:

If UE monitors GWUS according to clause 7.5.1:

this is the number of paging narrowbands (paging carriers) that are configured with GWUS.

else:

this is the number of paging narrowbands (paging carriers) provided in system information.

- UE\_ID:

If the UE supports E-UTRA connected to 5GC and NAS indicated to use 5GC for the selected cell:

5G-S-TMSI mod 1024, if P-RNTI is monitored on PDCCH.

5G-S-TMSI mod 16384, if P-RNTI is monitored on NPDCCH or MPDCCH.

else

IMSI mod 1024, if P-RNTI is monitored on PDCCH.

IMSI mod 4096, if P-RNTI is monitored on NPDCCH.

IMSI mod 16384, if P-RNTI is monitored on MPDCCH or if P-RNTI is monitored on NPDCCH and the UE supports paging on a non-anchor carrier, and if paging configuration for non-anchor carrier is provided in system information.

- W(i): Weight for NB-IoT paging carrier i.

- W: Total weight of all NB-IoT paging carriers, i.e. W = W(0) + W(1) + … + W(Nn-1). If UE monitors GWUS according to clause 7.5.1, Total weight of all NB-IoT paging carriers configured with GWUS.

IMSI is given as sequence of digits of type Integer (0..9), IMSI shall in the formulae above be interpreted as a decimal integer number, where the first digit given in the sequence represents the highest order digit.

For example:

 IMSI = 12 (digit1=1, digit2=2)

In the calculations, this shall be interpreted as the decimal integer "12", not "1x16+2 = 18".

5G-S-TMSI is a 48 bit long bit string as defined in TS 23.501 [39]. 5G-S-TMSI shall in the PF and i\_s formulae above be interpreted as a binary number where the left most bit represents the most significant bit.

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| Start of next change |

## 7.4 Paging with Wake Up Signal

If the UE is in RRC\_IDLE, the UE is not using GWUS according to clause 7.5 and the UE supports WUS and WUS configuration is provided in system information, the UE shall monitor WUS using the WUS parameters provided in System Information. When DRX is used and the UE detects WUS the UE shall monitor the following PO. When extended DRX is used and the UE detects WUS the UE shall monitor the following *numPOs* POs or until a paging message including the UE's NAS identity is received, whichever is earlier. If the UE does not detect WUS the UE is not required to monitor the following PO(s). If the UE missed a WUS occasion (e.g. due to cell reselection), it monitors every PO until the start of next WUS or until the PTW ends, whichever is earlier.

- *numPOs* = Number of consecutive Paging Occasions (PO) mapped to one WUS provided in system information where (*numPOs*≥1).

The WUS configuration, provided in system information, includes time-offset between end of WUS and start of the first PO of the *numPOs* POs UE is required to monitor. The timeoffset in subframes, used to calculate the start of a subframe *g*0 (see TS 36.213 [6]), is defined as follows:

- for UE using DRX, it is the signalled *timeoffsetDRX*;

- for UE using eDRX, it is the signalled *timeoffset-eDRX-Short* if *timeoffset-eDRX-Long* is not broadcasted;

- for UE using eDRX, it is the value determined according to Table 7.4-1 if *timeoffset-eDRX-Long* is broadcasted

Table 7.4-1: Determination of GAP between end of WUS and associated PO

|  |  |
| --- | --- |
|  | *timeoffset-eDRX-Long* |
| *1000ms* | *2000ms* |
| *UE Reported wakeUpSignalMinGap-eDRX* | ***40ms or not reported*** | *timeoffset-eDRX-Short* | *timeoffset-eDRX-Short* |
| ***240ms*** | *timeoffset-eDRX-Short* | *timeoffset-eDRX-Short* |
| ***1000ms*** | *timeoffset-eDRX-Long* | *timeoffset-eDRX-Long* |
| ***2000ms*** | *timeoffset-eDRX-Short* | *timeoffset-eDRX-Long* |

The timeoffset is used to determine the actual subframe *g*0 as follows (taking into consideration resultant SFN and/or H-SFN wrap-around of this computation):

*g*0 = PO – timeoffset, where PO is the Paging Occasion subframe as defined in clause 7.1

For UE using eDRX, the same timeoffset applies between the end of WUS and associated first PO of the *numPOs* POs for all the WUS occurrences for a PTW.

The timeoffset, *g*0, is used to calculate the start of the WUS as defined in TS 36.213 [6].

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| Start of next change |

### 7.5.1 General

When all of the following conditions are met then the UE shall monitor GWUS using the GWUS parameters provided in system information.

- the UE is in RRC\_IDLE;

- the UE supports GWUS;

- GWUS configuration (*gwus-Config*) is provided in system information;

- groupAlternation is present in *gwus-Config* and UE supports GWUS with group resource alternation or groupAlternation is not present in *gwus-Config*.

A UE supporting GWUS can be configured to monitor a WUS group and a common WUS. Upon detecting either of them, UE shall monitor POs as defined in clause 7.4.

For NB-IoT, E-UTRAN may configure up to 2 WUS resources (numbered 0 and 1). The timeoffset, *g*0, from the end of WUS resource 0 to the start of corresponding PO is determined as defined in clause 7.4. When both *wus-Config* and *gwus-Config* are present, WUS resource 0 shares radio resources with *wus-Config*.The timeoffset from the end of WUS esource 1 to the start of corresponding PO is sum of the timeoffset *g*0 and the maximum WUS duration.

After the UE has determined the applicable gap between end of WUS resource and associated PO as specified in clause 7.4, UE selects the WUS group set for the corresponding gap as specified in clause 7.5.2. From the selected WUS group set, UE selects one WUS group as defined in clause 7.5.3. If *groupAlternation* is not present in *gwus-Config*, the UE monitors the selected WUS group with the corresponding timeoffset for each PO. If *groupAlternation* is present in *gwus-Config* and UE supports GWUS with group resource alternation, the UE determines the WUS group to monitor for each PO and the corresponding timeoffset as specified in clause 7.5.4.

For BL UEs and UEs in enhanced coverage, E-UTRAN may configure up to 4 WUS resources. The resource number, time and frequency location of these resources is determined as specified in clause 7.5.5.

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| Start of next change |

### 7.5.2 WUS group sets selection

The total number of WUS groups, maxWG, configured for a gap is determined with the following equation:

where:

* maxWR is the total number of WUS resources configured for the gap.
* *numGroupsList*[i] is the number of WUS groups configured for WUS resource i, provided in *gwus-Config*, for the gap.

Using *numGroupsList* for the gap*,* the UE builds the list of WUS groups as an ordered list of pairs (, ) where the first entry corresponds to the first WUS group on the first configured WUS resource and the last entry corresponds to the last WUS group on the last configured WUS resource.

For a NB-IoT UE, if *resourcePosition* provided in *gwus-Config* is set to *secondary,*  = 0 is not used and the first entry in the list corresponds to = 1. Otherwise, is the index of the WUS resources in *numGroupsList*.

For a BL UE or UE in enhanced coverage, UE determines of the configured resources as specified in clause 7.5.4.

If *probThreshList* is present in *gwus-Config*, UE determines the WUS group sets as defined in Table 7.5.2.1. The total number of WUS group sets is equal to the number of entries in *probThreshList* + 1. The WUS groups are first assigned to WUS group set 1, followed by WUS group set 2, and so on. The UE determines the WUS group set corresponding to its probability PNAS, if configured, as defined in Table 7.5.2-1. If PNAS is not configured UE selects the WUS group set with highest index that has at least one WUS group (i.e. Upper bound – Lower bound > 0).

Table 7.5.2-1: WUS group set definition when *probThreshList* is configured

|  |  |  |
| --- | --- | --- |
| WUS group set | *probThreshList* | WUS group index in WUS groups list |
| Lower bound | Upper bound |
| 1 | PNAS ≤ Thresh1 | 0 | Nth1 -1 |
| 2 | Thresh1 < PNAS ≤ Thresh2 (Note) | Nth1 | Nth1 + Nth2 -1 |
| 3 | Thresh2 < PNAS ≤ Thresh3 (Note) | Nth1 + Nth2 | Nth1 +Nth2 + Nth3 -1 |
| 4 | PNAS > Thresh3 | Nth1 +Nth2 + Nth3 | maxWG-1 |
| where Threshi is the value signalled in the ith entry of *probThreshList* Nthi is the value signalled in the ith entry of *groupsForServiceList*Note: When the total number of WUS group sets is less than 4, the upper bound for the WUS group set with highest index is maxWG-1. |

If *probThreshList* is not present in *gwus-Config*, there is only one WUS group set containing all the WUS groups configured in *numGroupsList*. The total number of WUS groups is maxWG.

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| Start of next change |

### 7.5.3 WUS group selection

After selection of the WUS group set as specified in clause 7.5.2, the UE selects the WUS group to monitor as below.

For BL UE or UE in enhanced coverage, the UE determines wg with following equation:

For NB-IoT, the UE determines wg with following equation:

where:

* UE\_ID, N, Ns, Nn and W are defined in clause 7.1.
* Nw is the number of WUS groups in the selected WUS group set.
* wg is the index of the WUS group in the selected WUS group set, determined as defined in clause 7.5.2, 0 .. Nw-1.

If *probThreshList* is not present, WG = wg. If *probThreshList* is present, the UE determines WG, the index of the corresponding WUS group within the WUS groups list, as defined in Table 7.5.3-1.

Table 7.5.3-1: Index of the WUS group to monitor

|  |  |
| --- | --- |
| Selected WUS group set | WG |
| 1 | wg |
| 2 | wg + Nth1 |
| 3 | wg + Nth1 + Nth2 |
| 4 | wg + Nth1 + Nth2 + Nth3 |
| Where Nthi is defined in table 7.5.1  |

The entry corresponding to WG’in theWUS groups list defined in clause 7.5.2 provides (, as specified in TS 36.213 [6].

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| Start of next change |

### 7.5.4 WUS Group Alternation

If *groupAlternation* is present in *gwus-Config,* the UE determines the WUS group to monitor for the current PO as follows:

- if *probThreshList* is not present in *gwus-Config* and *commonSequence* is set to *g*0:

where:

- Tcell is the default DRX cycle for the cell.

- SFN is the SFN corresponding to the PO.

- H-SFN is the H-SFN corresponding to the PO.

- maxWG is the total number of WUS groups configured in *numGroupsList* for the gap.

- Gmin is the lowest number of WUS groups configured amongst all WUS resources for the gap.

- WGcurrent is the index of the WUS group to monitor for the current PO.

- WGinitial is the index, WG, of the WUS group determined in clause 7.5.3.

The entry corresponding to WGcurrent in the WUS groups list defined in clause 7.5.2 provides (, as specified in TS 36.213 [6].

- else:

where:

- Tcell is the default DRX cycle for the cell.

- SFN is the SFN corresponding to the PO.

- H-SFN is the H-SFN corresponding to the PO.

- maxWR is the total number of WUS resources configured in *numGroupsList* for the gap.

- minitial is defined based on given in the entry corresponding to the index WG determined in clause 7.5.3:

- For a NB-IoT UE : minitial

- For a BL UE or UE in enhanced coverage:

- if = 0 is used for GWUS:

 - minitial - 1

- else:

 - minitial

- mcurrent is used to determine of the WUS group to monitor for the current PO as follows:

- For a NB-IoT UE := mcurrent.

- For a BL UE or UE in enhanced coverage:

- if is used for GWUS:

- = mcurrent

- else:

- = mcurrent +1

 of the WUS group to monitor for the current PO is given in the entry corresponding to the index WG determined in clause 7.5.3.

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| Start of next change |

### 7.5.5 WUS Resource Location for BL UEs and UEs in Enhanced coverage

A BL UE or UE in enhanced coverage determines the time/frequency location of WUS resources based on the number of configured WUS resources and the frequency location of WUS resource 0 (. If *wus-Config* is present, frequency location for WUS resource 0 is defined by *frequencyLocation* parameter in *wus-Config*. Otherwise, frequency location for WUS resource 0 is defined by *resourceLocationWithoutWUS* in *gwus-Config*. The frequency location of other WUS resources (i.e., WUS resource 1, 2, 3), based on frequency location of WUS resource 0, is given in Table 7.5.5-1.

Table 7.5.5-1: WUS resource frequency location

|  |  |
| --- | --- |
| WUS resource() | Frequency location of WUS resource ID 0 |
| n0 | n2  | n4 (NOTE 1) |
| NB frequency < centre frequency | NB frequency > centre frequency  |
| WUS resource 1,3 | n2 | n4 | n0 | n2 |
| WUS resource 2 | n0 | n2 | n2 | n4 |
| WUS resource 2(NOTE 2) | n4 | n0 | n4 | n0 |
| NOTE 1: This column is applicable if *wus-Config* is present.NOTE 2: This row is applicable if *resourceLocationWithWUS* is *primary3FDM*. |

The timeoffset, *g*0, from the end of WUS resource 0 and WUS resource 1 to the start of corresponding PO is determined as defined in clause 7.4. Except when *resourceLocationWithWUS* is set to *primary3FDM* , the timeoffset from the end of WUS resource 2 and WUS resource 3 to the start of corresponding PO is sum of the timeoffset *g*0 and the maximum WUS duration. When *resourceLocationWithWUS* is set to *primary3FDM*, the timeoffset for WUS resource 2 is same as WUS resource 0 and 1.

The resource pattern ID (rp-ID) which indicates the WUS resources applicable for GWUS is derived based on *resourceMappingPattern* and the configured number of WUS resources as follows:

If *resourceLocationWithWUS* is configured:

rp-ID = 2\*(maxWR -– 1) if *resourceLocationWithWUS* is set to *primary*.

rp-ID = 2\*maxWR - 1 if *resourceLocationWithWUS* is set to *secondary*.

rp-ID = 7 if *resourceLocationWithWUS* is set to *primary3FDM*.

If *resourceLocationWithoutWUS* is configured:

rp-ID = 2\*(maxWR - 1)

where maxWR is the total number of WUS resources configured in *numGroupsList* for the gap.

The WUS resource IDs corresponding to the resource pattern ID are determined as defined in Table 7.5.5-2.

Table 7.5.5-2: WUS resources applicable for Resource Pattern

|  |  |
| --- | --- |
|  | Resource Pattern ID |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| WUS resource*()* | 0 | X |  | X |  | X |  | X | X |
| 1 |  | X | X | X | X | X | X | X |
| 2 |  |  |  | X | X | X | X | X |
| 3 |  |  |  |  |  | X | X |  |

If = 0 is not used, the first entry in the *numGroupsList* corresponds to = 1. Otherwise, is the index of the WUS resources in *numGroupsList*.

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| End of change |