**3GPP TSG-RAN WG2 Meeting #109eR2-2001788**

**Online, February 24th – 6th March 2020**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
|  |
|  | **36.304** | **CR** | **0783** | **rev** | **1** | **Current version:** | **15.5.0** |  |
|  |
| *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:***  | Introduction of Rel-16 NB-IoT enhancements |
|  |  |
| ***Source to WG:*** | Nokia |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NB-IoTenh3-Core |  |  | 2019-03-10 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***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:*** | To capture the agreements for Rel-16 NB-IoT Enhancements impacting 36.304 specification |
|  |  |
| ***Summary of change:*** | Introduction of Rel-16 NB-IOT enhancements.* Improved multi-carrier operation

Translation of RSRP measurements at non-anchor carrier for consideration in cell selection criteria.* PO calculation changes using 5G-S-TMSI for NB-IoT
* Support of GWUS
* NRS presence on non anchor carrier in NB-IOT.

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| ***Consequences if not approved:*** | Rel-16 NB-IoT enhancements will not be supported. |
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| ***Clauses affected:*** | 5.2.3.2a, 5.2.4.7,7.1,7.4 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS 36.331 CR xxxx |
| ***affected:*** | **X** |  |  Test specifications | TS 36.306 CR xxxx  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |

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| ***This CR's revision history:*** | R2-1914593 – Initial version for RAN2-108. For RAN2-107bis agrrements.R2-1916565 - V2.Additional changes from RAN2-108 Agreements.R2-2002090 – CR based on endorsed running CR for RAN2-108 Agreements.R2-2001788 – RAN2 agreements from RAN2-109e for NRS presence on non anchor carrier in NB-IoT.  |

First Change

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

1xRTT CDMA2000 1x Radio Transmission Technology

AS Access Stratum

AC Access Class (of the USIM)

ACDC Application specific Congestion control for Data Communication

BCCH Broadcast Control Channel

BL Bandwidth reduced Low complexity

BR-BCCH Bandwidth Reduced Broadcast Control Channel

BSS Basic Service Set

CMAS Commercial Mobile Altert System

CSG Closed Subscriber Group

DRX Discontinuous Reception

DL-SCH Downlink Shared Channel

EHPLMN Equivalent Home PLMN

EPC Evolved Packet Core

EPS Evolved Packet System

ETWS Earthquake and Tsunami Warning System

E-UTRA Evolved UMTS Terrestrial Radio Access

E-UTRAN Evolved UMTS Terrestrial Radio Access Network

FDD Frequency Division Duplex

GERAN GSM/EDGE Radio Access Network

GWUS Group Wake Up Signal

HPLMN Home PLMN

HSDN High Speed Dedicated Network

H-SFN Hyper System Frame Number

HRPD High Rate Packet Data

IMSI International Mobile Subscriber Identity

MBMS Multimedia Broadcast-Multicast Service

MBSFN Multimedia Broadcast multicast service Single Frequency Network

MCC Mobile Country Code

MCCH Multicast Control Channel

MDT Minimization of Drive Tests

MM Mobility Management

MNC Mobile Network Code

MPDCCH MTC Physical Downlink Control Channel

MTCH Multicast Traffic Channel

NAS Non-Access Stratum

NB-IoT NarrowBand Internet of Things

NR NR Radio Access

PLMN Public Land Mobile Network

ProSe Proximity-based Services

PSM Power Saving Mode

PTW Paging Time Window

PWS Public Warning System

RAT Radio Access Technology

RNA RAN-based Notification Area

RNAU RAN-based Notification Area Update

RRC Radio Resource Control

SAP Service Access Point

SIBX SystemInformationBlockTypeX

TDD Time Division Duplex

UAC Unified Access Control

UE User Equipment

UMTS Universal Mobile Telecommunications System

USIM Universal Subscriber Identity Module

UTRA UMTS Terrestrial Radio Access

UTRAN UMTS Terrestrial Radio Access Network

V2X Vehicle-to-Everything

WUS Wake Up Signal

Next Change

#### 5.2.3.2a Cell Selection Criterion for NB-IoT

If the measurements are performed on the non-anchor carrier and UE meets the requirements specified in TS 36.133 [10] the cell selection criterion S is fulfilled when:

 Srxlev > 0

Else, the cell selection criterion S is fulfilled when:

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| Srxlev > 0 AND Squal > 0 |

where:

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| Srxlev = Qrxlevmeas – Qrxlevmin – Pcompensation - QoffsettempSqual = Qqualmeas – Qqualmin - Qoffsettemp |

where:

|  |  |
| --- | --- |
| Srxlev | Cell selection RX level value (dB) |
| Squal | Cell selection quality value (dB) |
| Qoffsettemp | Offset temporarily applied to a cell as specified in TS 36.331 [3] (dB) |
| Qrxlevmeas | Measured cell RX level value (RSRP).If RSRP is measured on non-anchor carrier of the cell, the measured RSRP value is translated to Qrxlevmeas as below. Qrxlevmeas = QrxlevmeasNonAnchor - *nrs-PowerOffsetNonAnchor*.Where QrxlevmeasNonAnchor is the Measured RX level (RSRP) of the non-anchor carrier. |
| Qqualmeas | Measured cell quality value (RSRQ) |
| Qrxlevmin | Minimum required RX level in the cell (dBm)If UE is not authorized for enhanced coverage and Qoffsetauthorization is valid then Qrxlevmin = Qrxlevmin + Qoffsetauthorization. |
| Qqualmin | Minimum required quality level in the cell (dB) |
| Pcompensation  | If the UE supports the *additionalPmax* in the *NS-PmaxList-NB*, if present, in SIB1-NB, SIB3-NB and SIB5-NB:max(PEMAX1 –PPowerClass, 0) – (min(PEMAX2, PPowerClass) – min(PEMAX1, PPowerClass)) (dB);else:if PPowerClass is 14 dBm:max(PEMAX1 –(PPowerClass – Poffset), 0) (dB);else:max(PEMAX1 –PPowerClass, 0) (dB) |
| PEMAX1, PEMAX2 | Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as PEMAX in TS 36.101 [33]. PEMAX1 and PEMAX2 are obtained from the *p-Max* and the *NS-PmaxList-NB* respectively in SIB1-NB, SIB3-NB and SIB5-NB as specified in TS 36.331 [3]. |
| PPowerClass | Maximum RF output power of the UE (dBm) according to the UE power class as defined in TS 36.101 [33] |

Next Change

5.2.4.7 Cell reselection parameters in system information broadcasts

Cell reselection parameters are broadcast in system information and are read from the serving cell as follows:

**cellReselectionPriority**

This specifies the absolute priority for E-UTRAN frequency or NR frequency or UTRAN frequency or group of GERAN frequencies or band class of CDMA2000 HRPD or band class of CDMA2000 1xRTT.

**cellReselectionSubPriority**

This specifies the fractional priority value added to cellReselectionPriority for E-UTRAN frequency or NR frequency.

**nrs-PowerOffsetNonAnchor**

This specifies the the power offset of the downlink narrowband reference-signal EPRE of the anchor/non-anchor carrier relative to the anchor carrier for NB-IoT UE.

**Poffset**

This specifies the offset for 14 dBm power class for BL or NB-IoT UE.

**Qoffsetauthorization**

This specifies the offset for enhanced coverage authorization for NB-IoT.

**Qoffsets,n**

This specifies the offsetbetween the two cells.

**Qoffsetfrequency**

Frequency specific offset for equal priority E-UTRAN frequencies.

**Qoffsetscptm**

This specifies the offset to be used for cell re-selection for SC-PTM service reception for BL UE, UE in enhanced coverage and NB-IoT UE. The same offset is applicable to all frequencies providing MBMS services via SC-PTM.

**Qoffsettemp**

This specifies the additional offset to be used for cell selection and re-selection. It is temporarily used in case the T300 expires consecutively on the cell as specified in TS 36.331 [3].

**Qhyst**

This specifies the hysteresis value for ranking criteria.

**Qqualmin**

This specifies the minimum required quality level in the cell in dB.

**Qqualmin\_CE, Qqualmin\_CE1**

This specifies the coverage specific minimum required quality level in the cell in dB.

**Qrxlevmin**

This specifies the minimum required Rx level in the cell in dBm.

**Qrxlevmin\_CE, Qrxlevmin\_CE1**

This specifies the coverage specific minimum required Rx level in the cell in dBm.

**RedistributionFactorFreq**

This specifies the redistribution factor for a neighbour E-UTRAN frequency.

**RedistributionFactorCell**

This specifies the redistribution factor for a neighbour E-UTRAN cell.

**RedistributionFactorServing**

This specifies the redistribution factor for serving cell or serving frequency.

**TreselectionRAT**

This specifies the cell reselection timer value. For each target E-UTRA frequency and for each RAT (other than E-UTRA) a specific value for the cell reselection timer is defined, which is applicable when evaluating reselection within E-UTRAN or towards other RAT (i.e. TreselectionRAT for E-UTRAN is TreselectionEUTRA, for NR TreselectionNR, for UTRAN TreselectionUTRA for GERAN TreselectionGERA, for TreselectionCDMA\_HRPD, and for TreselectionCDMA\_1xRTT). For NB-IoT intra-frequency and inter-frequency specific values for the cell reselection timer are defined, which are applicable when evaluating reselection within NB-IoT.

NOTE: TreselectionRAT is not sent on system information, but used in reselection rules by the UE for each RAT.

**TreselectionEUTRA\_ CE**

This specifies the cell reselection timer value TreselectionRAT for E-UTRAN when a neighbour cell is evaluated for camping in enhanced coverage. The parameter can be set per E-UTRAN frequency.

**TreselectionEUTRA**

This specifies the cell reselection timer value TreselectionRAT for E-UTRAN. The parameter can be set per E-UTRAN frequency TS 36.331 [3].

**TreselectionNR**

This specifies the cell reselection timer value TreselectionRAT for NR.

**TreselectionNB-IoT\_Intra**

This specifies the intra-frequency cell reselection timer value TreselectionRAT for NB-IoT.**TreselectionNB-IoT\_Inter**

This specifies the inter-frequency cell reselection timer value TreselectionRAT for NB-IoT.

**TreselectionUTRA**

This specifies the cell reselection timer value TreselectionRAT for UTRAN.

**TreselectionGERA**

This specifies the cell reselection timer value TreselectionRAT for GERAN.

**TreselectionCDMA\_HRPD**

This specifies the cell reselection timer value TreselectionRAT for CDMA HRPD.

**TreselectionCDMA\_1xRTT**

This specifies the cell reselection timer value TreselectionRAT for CDMA 1xRTT.

**ThreshX, HighP**

This specifies the Srxlev threshold (in dB) used by the UE when reselecting towards a higher priority RAT/ frequency than the current serving frequency. Each frequency of E-UTRAN, NR and UTRAN, each group of GERAN frequencies, each band class of CDMA2000 HRPD and CDMA2000 1xRTT might have a specific threshold.

**ThreshX, HighQ**

This specifies the Squal threshold (in dB) used by the UE when reselecting towards a higher priority RAT/ frequency than the current serving frequency. Each frequency of E-UTRAN, NR and UTRAN FDD might have a specific threshold.

**ThreshX, LowP**

This specifies the Srxlev threshold (in dB) used by the UE when reselecting towards a lower priority RAT/ frequency than the current serving frequency. Each frequency of E-UTRAN, NR and UTRAN, each group of GERAN frequencies, each band class of CDMA2000 HRPD and CDMA2000 1xRTT might have a specific threshold.

**ThreshX, LowQ**

This specifies the Squal threshold (in dB) used by the UE when reselecting towards a lower priority RAT/ frequency than the current serving frequency. Each frequency of E-UTRAN, NR and UTRAN FDD might have a specific threshold.

**ThreshServing, LowP**

This specifies the Srxlev threshold (in dB) used by the UE on the serving cell when reselecting towards a lower priority RAT/ frequency.

**ThreshServing, LowQ**

This specifies the Squal threshold (in dB) used by the UE on the serving cell when reselecting towards a lower priority RAT/ frequency.

**SIntraSearchP**

This specifies the Srxlev threshold (in dB) for intra-frequency measurements.

**SIntraSearchQ**

This specifies the Squal threshold (in dB) for intra-frequency measurements.

**SnonIntraSearchP**

This specifies the Srxlev threshold (in dB) for E-UTRAN inter-frequency and inter-RAT measurements.

**SnonIntraSearchQ**

This specifies the Squal threshold (in dB) for E-UTRAN inter-frequency and inter-RAT measurements.

SSearchDeltaP

This specifies the Srxlev delta threshold (in dB) during relaxed monitoring.

Next 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, 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.

- 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 supports group WUS and g*wus-Config-r16* is present in system information:

this is the number of paging narrowbands (paging carriers) that support group WUS.

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).

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.

Next Change

## 7.4 Paging with Wake Up Signal

When 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 the UE supports GWUS and GWUS configuration is provided in system information, UE shall monitor WUS using the GWUS parameters provided in System Information as defined in sub clause 7.y.. 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 subclause 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].

Next Change

## 7.x Paging with Group Wake Up Signal

## 7.x.1 General

When the UE supports GWUS and GWUS configuration (*gwus-Config*) is provided in system information, the UE shall monitor GWUS using the GWUS parameters provided in System Information. A UE supporting GWUS can be configured to monitor a group WUS and a common WUS. Upon detecting either of the WUS, UE shall monitor POs as defined in subclause 7.4.

For NB-IoT, E-UTRAN may configure up to 2 WUS resources (numbered 0 and 1). For BL UE and UE in enhanced coverage, E-UTRAN may configure up to 4 WUS resources (numbered 0, 1, 2, and 3).(See TS 36.300 [2] ).

The time offset, *g*0, from the end of WUS resource 0 to the start of corresponding PO is determined as defined in subclasue 7.4. When both *wus-Config-r15* and g*wus-Config-r16* are present, WUS resource 0 shares radio resources with *wus-Config-r15*.

For NB-IoT, the time offset from the end of WUS resource 1 to the start of corresponding PO is sum of the time offset *g*0 and the maximum WUS duration. For BL UE and UE in enhanced coverage, the time offset from the end of WUS resource 1, 2 or 3 to the start of corresponding PO depends on the resource mapping pattern.

For BL UE and UE in enhanced coverage, the frequency location within a narrowband for each WUS resource is determined as defined in subclase 7.x.4

UE selects the WUS group set as specified in subclause 7.x.2. From the selected WUS group set, UE selects one WUS group as defined in subcaluse 7.x.3.

### 7.x.2 WUS group sets selection

### 7.x.3 WUS group selection

### 7.x.4 WUS resource frequency

Next Change

## 7.y NRS presence on non-anchor paging carrier in NB-IoT

For FDD, when *nrs-NonAnchorConfig* is signalled in system information, the POs associated with NRS are determined using the DRX parameters broadcast in *systeminformationBlockType2-NB*:

- T is the value of *defaultPagingCycle* broadcast in system information.

- nB is the value corresponding to *nB* broadcast in system information: 4T, 2T, T, T/2, T/4, T/8, T/16, T/32, T/64, T/128, T/256, T/512, and T/1024.

The POs are determined by:

 - Paging Frame (PF) given by: SFN mod T= (T div N) \* k

where:

- N: min(T, nB)

- k: 0, 1, .., N-1

- Index i\_s pointing to PO from subframe pattern defined in 7.2.

where Ns: max(1,nB/T)

The POs associated with NRS are determined as follows:

- if nB is equal to 4T, 2T, T or T/2:

POs for which R = 1 have associated NRS

where:

R = (PO\_Index+ offset) mod 2

where:

- PO\_Index = (SFN/ T \* nB + i\_s) mod nB

- Offset = (FLOOR ((SFN + 1024\*H-SFN) / T)) mod 2

- SFN is the SFN corresponding to the PO

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

- i\_s is the index i\_s corresponding to the PO

- else:

all POs have associated with NRS.

Next Change