**3GPP TSG-RAN WG2 Meeting #117-e R2-2204239**

**Electronic, 21st Feb. – 3rd Mar. 2022**

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| *CR-Form-v12.2* |
| **CHANGE REQUEST** |
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|  | **38.304** | **CR** | **0227** | **rev** | **1** | **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 | **X** | Core Network |  |

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| ***Title:***  | Introduction of ePowSav in TS 38.304  |
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| ***Source to WG:*** | vivo (Rapporteur) |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NR\_UE\_pow\_sav\_enh-Core |  | ***Date:*** | 2022-03-10 |
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| ***Category:*** | **B** |  | ***Release:*** | Rel-17 |
|  | *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-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19)* |
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| ***Reason for change:*** | Introduction of ePowSav features in NR. This CR captures the idle/inactive aspects of enhanced power saving and it is based on the below RAN2/RAN1 agreements. On PEI and subgrouping:

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| **RAN2 agreements** | **Impacted specification** |
| If we go for network controlled subgrouping, If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID). | Captured in 7.y.2 |
| CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics | Captured in 7.y.1 |
| Use same UE subgroups when in RRC\_IDLE and RRC\_INACTIVE | Captured in 7.y |
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| When AMF has assigned a UE with a Paging subgroup, some NAS signaling should be supported between AMF and UE to convey the related information to the UE. Exact information is FFS. The design and procedure are up to SA2/CT1. | Captured in 7.y.1 |
| When AMF has assigned a UE with a Paging subgroup, some signaling should be supported between AMF and gNB(s) to inform gNB(s) about the related subgroup information for paging a UE in RRC\_IDLE/RRC\_INACTIVE. Exact information is FFS. The message(s) and associated design are up to RAN3. | Captured in 7.y.1 |
| UEID-based subgroup method requires, in addition to the already available information for legacy UEID-based grouping in PO, the total number of supported UEID-based subgroups by the network. | Captured in 7.y.2 |
| At least for UEID-based subgroup method the total number, Nsg, of supported subgroups by the network is decided by RAN and broadcasted in System Information. | Captured in 7.y.2 |
| At least for UEID-based subgroup method the total number, Nsg, of supported subgroups is controlled on a cell basis and can be different in different cells. | Captured in 7.y.2 |
| Option 2 is excludedWe go with Option 1*Editor’s NOTE: option 1 and option 2 come from R2-2109094, which are:** ***Option 1:*** *CN assigns subgroup ID*
	+ *possible with or without remapping to RAN subgroup ID depends on the sub-options*
* ***Option 2:*** *CN assigns a set of subgroup IDs*
	+ *Similar to option 1 but with multiple subgroup IDs assigned from CN and the UE needs to choose the corresponding subgroup ID based on RAN configuration*
 | Captured in 7.y.1 |
| R2 assumes that All the cells within the registration area supports the same number of CN assigned subgroups, i.e. no remapping of CN assigned group ID to RAN subgroup ID (will revisit only if serious issues are found).  | Captured in 7.y.1 |
| RAN capability is known based on broadcast information. FFS with explicit indication or implicitly based configuration. | Captured in 7.y |
| Assume that one subgroup indication refer to either CN assigned subgroups or UE-ID based subgroup (no overlapping)Both UE ID based and CN based subgrouping can be supported simultaneously in a cell, it is allowed to just support one of them.  | Captured in 7.y.0 |
| RAN introduces a new parameter Nsg-UEID to indicate its support of UE-ID based subgrouping. | Captured in 7.y.2 |
| RAN does not support any type of subgrouping if its configuration for subgrouping is either absent or nullified (e.g. subgroupsNumPerPO is either absent or set to zero). FFS for the signalling details. | Captured in 7.y.0 |
| We assume separate indications for UE capability of CN based subgrouping and UEID based subgrouping. UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while R2 assumes that UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. | Captured in 7.y.1 and 7.y.2 |
| RAN2 assumes that if PEI is detected, and the PEI indicates that the UE has to monitor the associated PO, then the UE monitors paging DCI in the associated PO, including scheduling information for paging PDSCH (if included) as in legacy. This assumption may be updated based on RAN1 agreements. | Captured in 7.x.1 |
| As a baseline RAN2 has a preference to support PEI with both DRX and eDRX, but potential issues (e.g. PEI and PTW) are FFS. | Captured in 7.x.1 |
| For UE-ID based subgroups the UE identity is UE\_ID = 5G-S-TMSI mod X, where X is 8192 (1024\*8).  | Captured in 7.y.2 |
| If the UE was not able to monitor the PEI occasion corresponding to its PO the UE shall monitor the PO. | Captured in 7.x.1 |
| RAN configuration (of subgrouping) includes the two parameters Nsg-UEID (number of UEID-based subgroups) and *subgroupsNumPerPO* (total number of subgroups in a PO):- If only CN-assigned subgrouping is used, *subgroupsNumPerPO* is present (the value then equals to the number of CN-assigned subgroups), and Nsg-UEID is absent.- If only UEID-based subgrouping is used, *subgroupsNumPerPO* and Nsg-UEID are present, and Nsg-UEID has the same value as *subgroupsNumPerPO*.- If both subgrouping methods are used, both *subgroupsNumPerPO* and Nsg-UEID are present, and 0 < Nsg-UEID < *subgroupsNumPerPO*. | Captured in 7.y.0 |
| RAN2 aims to Support PEI and subgrouping with eDRX. FFS the impact.  | Captured in 7.x.1 as an EN to wait for further progress. |
| RAN2 assumes that PEI can be used “without” subgrouping. FFS whether the bits in the PEI for subgrouping then need to have any particular meaning, or whether this would be done by just having one subgroup.  | Captured in 7.y.0FFS part is assumed to be captured by RAN1. |
| If network supports PEI but not subgrouping, the whole *SubgroupConfig-r17* is absent. The parameter *subgroupsNumPerPO* is mandatory present if *subgroupConfig-r17* is configured. | Captured in 7.y.0 |
| UE is configured to monitor PEI, either only in the last used cell or any other cells (after cell reselection). FFS how the configuration is provided in [SI, RRCRelease, or NAS message]. | Captured in 7.x.1 |
| If a cell supports both UE identity based and CN assigned subgrouping, for UEID based paging subgrouping, UE belongs to k-th paging subgroup, where- k = [floor (UE Identity/(N\*Ns)) mod Nsg-UEID] + Nsg-CN, - N is the number of Paging frames, - Ns is the number of POs per paging frame, - Nsg-UEID is the number of UEID-based paging subgroups, and - Nsg-CN is the number of CN assigned paging subgroups (= subgroupNumPerPO - Nsg-UEID). | Captured in 7.y.2 |
| Paging enhancement capability(-ies) (e.g. PEI capability, UEID based subgrouping capability or the combined capability of PEI and UEID based subgrouping) are ‘optional with capability signalling’ as gNB needs to know the paging enhancement capability(-ies) to page the UESeparate indications for UE capability of CN based subgrouping and UEID based subgrouping (confirms earlier assumption)UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. (confirms earlier assumption). | Partially captured in 7.x.1, 7.y.1, 7.y.2.Details assuming to be captured in RRC and TS 38.306. |
| Specify that the UEs that expect group notification ignores PEI (and just monitor paging as usual)*Editor’s NOTE: This conclusion was made in MBS WI session* | Captured in 7.y.0 |
| Network indicates whether UE monitors PEI in last used cell in system information. | Captured in 7.x.0 |
| RAN2 clarifies the meaning of “last used cell only”: When a cell broadcasts “last used cell only”, a UE monitors PEI only if its last connection was released by this cell. | Captured in 7.x.0 |
| RAN2 confirms that “PEI without subgrouping” can be implemented by configuring PEI plus UEID subgrouping with one subgroup.“PEI without subgrouping” can be configured by only one method. | Captured in 7.x.0 |
| When PEI is applied with eDRX, the UEID for UEID-based subgrouping is determined by 5G-S-TMSI mod 32768. | Captured in 7.y.2 |
| If a UE cannot find its subgroup ID with the PEI configurations in a cell, it monitors legacy paging. | Captured in 7.y.0 |
| A UE with CN-assigned subgroup ID should derive UEID-based subgroup ID in a cell supporting only UEID-based subgrouping. | Captured in 7.y.2 |
| **RAN1 agreements** | **Impacted specification** |
| For the evaluation and comparison of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, the following are assumed:* Behv-A:
	+ PEI indicates UE should monitor a PO if UE’s group/subgroup is paged
	+ UE is not required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO
* Behv-B:
	+ PEI indicates whether or not UE should monitor a PO
	+ UE is required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO

Rapporteur: Further conclusion in RAN#93 below should be considered together.* Support PDCCH-based PEI as the only option

•       Only essential function for PEI is support•      New DCI format•      Higher layer configuration, including SS•      Details of the procedures of PEI monitoring, and identification of MOs before PO•      Only Behv-A (per RAN1#104e agreement) is supported •      If TRS availability indication is agreed to be supported in both paging DCI and the DCI format for PEI, same mechanism/principle for TRS availability indication is adopted for the two DCI formats•      Supporting TRS availability indication in DCI format for PEI shall not delay the completion of essential functionality of PEI  | Captured in 7.x.1 |
| For NR Rel-17, paging indications to UE subgroups are carried only in PEI. | Captured in 7.y.0 |
| For PEI, a new DCI format is supported to include at least paging indications to UE group(s)/subgroups of the associated PO(s)* One bit in the DCI payload indicating one UE subgroup of a PO or one UE group/PO
* The maximum number of total bits for paging indication field in PEI DCI format is x
	+ One PEI can be configured to indicate up to 4 PO(s) in a PF
		- FFS whether to supporting map PEI to 3 POs in a PF
	+ FFS: 1 PEI for POs across multiple PFs
	+ FFS: value of x
 | Captured in 7.x.1 |
| A PEI occasion (PEI-O) is a set of *S* consecutive PDCCH monitoring occasions when *nrofPDCCH-MonitoringOccasionPerSSB-InPO* is not configured* *S* is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in SIB1
* The *K*-th PDCCH monitoring occasion for PEI in the PEI-O has the same QCL assumption as that of the *K*-th PDCCH monitoring occasion for paging in the PO.
	+ Note: QCL reference is SSB
* FFS: Determination of the PEI-O location
* FFS: Support of unlicensed spectrum operation with *nrofPDCCH-MonitoringOccasionPerSSB-InPO* configured
 | Captured in 7.x.1 |
| CORESET # 0 or *commonControlResourceSet* in SIB1 can be used for PEI* Note: The number of CORESETs configured for a UE follows the requirement of UE feature 3-1

Support configuration of a dedicated search space (‘peiSearchSpace’) for PEI* FFS: Configuration details and whether and how to reuse legacy search space sets, including *pagingSearchSpace* and *searchSpaceSetZero*
 | Captured in 7.x.1 |
| For unlicensed operation,A PEI-O is a set of 'S\*X ' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1* and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPO* if configured or is equal to 1 otherwise. The [x\*S+K]th PDCCH monitoring occasion for PEI in the PEI-O corresponds to the Kth transmitted SSB, where x=0,1,…,X-1, K=1,2,…,S.* If X > 1, when the UE detects a PEI within its PEI-O, the UE is not required to monitor the subsequent monitoring occasion(s) associated with the same PEI-O

Note: The QCL reference is SSB | Captured in 7.x.1 |
| Support mapping one PEI to *POnumPerPEI* PO(s) in one or multiple PF(s)        *POnumPerPEI* is a factor of  (total PO number in a paging cycle) and configurable via SIB for the cell with the value range of {1, 2, 4, 8}* The Maximum number of PF associated with one PEI is up to 2

        Note: Maximum number of paging indication bits in DCI format 2\_7 can be kept the same for any configuration of *POnumPerPEI*, e.g., by applying a smaller *subgroupsNumPerPO* and a larger *POnumPerPEI.*        Note: Larger value of *POnumPerPEI* can reduce the average PEI overhead per PO, but there can also cause potentially larger paging latency and larger UE power consumption due to longer UE wake-up time before PO monitoring, which can be significant with large value of (*T/N*). | Partially captured in 7.x.1 |
| * Determination of PEI-O location for UE’s PO is based on deciding a reference point and an offset from the reference point to the start of the first PDCCH MO of the PEI-O.

o   The reference point is the start of a reference frame determined by a frame-level offset from the start of the first PF of the PF(s) associated with the PEI-O and configured via SIB for the cell.* + - FFS: The range of the frame-level offset

o   There is a symbol-level offset from the reference point to the start of the first PDCCH MO of PEI-O, provided by firstPDCCH-MonitoringOccasionOfPEI-O and configured via SIB for the cell.* + - FFS: The range of the symbol-level offset
* Note: When PEI-O is placed close to or overlapped with an earlier SS burst before its associated POs, the total UE wake-up time can be reduced for better power saving gain. Network can configure the PEI-O location accounting the power saving benefit and potential impact on gNB flexibility.
 | Captured in 7.x.1 |
| *‘peiSearchSpace’* can be configured to one of up to 4 common SS sets configured by commonSearchSpaceList with *SearchSpaceId*> 0 | Captured in 7.x.1 |
| * The PDCCH monitoring occasions defined by *peiSearchSpace* colliding with UL symbols are omitted from the determination of the PEI monitoring occasions. The PDCCH monitoring occasions for PEI which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for PEI in the PEI-O.
 | Captured in 7.x.1 |
| If one PEI-O is associated with POs of 2 PFs,* The two PFs are consecutive PFs configured in SIB
	+ FFS: two PFs are consecutive PFs within the same paging cycle
* Note: As an example, SFN of the first PF of the PF(s) associated with the PEI-O can be obtained by: (SFN of UE’s PF) - $\left⌊i\_{PO}/N\_{s}\right⌋⋅T/N$
 | Captured in 7.x.1 |
| ConclusionSFN of the first PF of the PF(s) associated with the PEI-O is provided by (SFN of UE’s PF) -  | Captured in 7.x.1 |
| * Confirm the following working assumption:

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| *SearchSpaceId = 0* can be configured for *peiSearchSpace* for the case of CORESET multiplexing pattern 2 or 3 |

* When *SearchSpaceId* = 0 is configured for *peiSearchSpace*, subject to SS/PBCH block and CORESET multiplexing pattern 2 or 3, the PDCCH monitoring occasions for PEI-O are same as for RMSI as defined in clause 13 in TS 38.213.
* UE determines first PDCCH MO for PEI-O based on *PEI-F\_offset* and *firstPDCCH-MonitoringOccasionOfPEI-O*, as previously agreed for the case with *SearchSpaceId* > 0.
	+ Note: UE expects the first PDCCH MO for PEI-O determined from *PEI-F\_offset* and *firstPDCCH-MonitoringOccasionOfPEI-O* is aligned with the MOs for RMSI as defined in clause 13 in TS 38.213.
 | Captured in 7.x.1 |

On TRS:

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| RAN2 agreements | **Impacted specification** |
| * The TRS/CSI-RS configuration is provided in a new SIB.
* On demand SI should be possible for the SIB with TRS/CSI-RS information.
 | Captured in Z |
| * RAN2 assumes to support current RAN1 working agreement of L1 based signalling for TRS/CSI-RS availability indication. FFS whether it should be possible to enable / disable the TRS/CSI-RS L1 based availability mechanism by broadcast signalling.
 | Captured in Z |
| **RAN1 agreements** | **Impacted specification** |
| Agreement:Confirm the following working assumption:Support at least L1 based signaling for the availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs.* FFS details, including paging DCI and/or PEI for L1 based signaling
* FFS SIB-based signaling/configuration
	+ Note: It is RAN1 understanding that existing SI update procedure is used for SIB based signalling

 Agreement:For the information provided by a physical layer availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs, support availability/unavailability information for configured RS resources using a bitmap or codepoint* e.g. using bitmap, where each bit is associated with at least one resource/configuration or a set/group of resources
* e.g. a codepoint to indicate a state of availability/unavailability for all or some of configured RS resources
* FFS maximum number of configured RS resources per physical layer availability indication to support.
* FFS whether availability/unavailability information is for all or some of configured RS resources
 | Captured in Z |
| Support paging PDCCH based availability indication of TRS/CSI-RS occasions for idle/inactive UEs.Support PEI based availability indication of TRS/CSI-RS occasions for idle/inactive UEs at least if PDCCH-based PEI is down-selected.* FFS how to enable/disable L1 based availability indication configurable by SIB
 | Captured in Z |
| AgreementFor the validity duration configured by higher layer at least for paging PDCCH based L1 availability indication, support* time unit is one default paging cycle,
* applicable values: {1, 2, 4, 8, 16, 32, [64], [128], [256],[512]}

When the validity duration is not configured, UE assumes a default time duration to be 2 default paging cycle(s). | Partially captured in Z |

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| ***Summary of change:*** | In summary, below RAN2 agreements are captured:* In 3.2, add the abbreviations for PEI, PEI-O, TRS
* In 7.x, add the function of PEI
* In 7.y, add the function of CN assigned subgrouping and UE\_ID based subgrouping.
* In Z, add the function of TRS
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| ***Consequences if not approved:*** | Rel-17 UE ePowSav is not supported in NR in TS 38.304. |
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| ***Clauses affected:*** | 3.2, 7.x, 7.y, Z |
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|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS/TR 38.331 CR 2924TS/TR 38.300 CR 0417 |
| ***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

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AS Access Stratum

CAG Closed Access Group

CAG-ID Closed Access Group Identifier

CMAS Commercial Mobile Alert System

CN Core Network

DCI Downlink Control Information

ETWS Earthquake and Tsunami Warning System

E-UTRA Evolved UMTS Terrestrial Radio Access

E-UTRAN Evolved UMTS Terrestrial Radio Access Network

HRNN Human-Readable Network Name

IAB Integrated Access and Backhaul

IMSI International Mobile Subscriber Identity

MCC Mobile Country Code

MICO Mobile Initiated Connection Only

NAS Non-Access Stratum

NID Network Identifier

NPN Non-Public Network

NR NR Radio Access

PEI Paging Early Indication

PEI-O Paging Early Indication-Occasion

PLMN Public Land Mobile Network

RAT Radio Access Technology

RNA RAN-based Notification Area

RNAU RAN-based Notification Area Update

RRC Radio Resource Control

SNPN Stand-alone Non-Public Network

TRS Tracking Reference Signal

UAC Unified Access Control

UE User Equipment

UMTS Universal Mobile Telecommunications System

V2X Vehicle to Everything

Next change

# 7 Paging

## 7.1 Discontinuous Reception for paging

The UE may use Discontinuous Reception (DRX) in RRC\_IDLE and RRC\_INACTIVE state in order to reduce power consumption. The UE monitors one paging occasion (PO) per DRX cycle. A PO is a set of PDCCH monitoring occasions and can consist of multiple time slots (e.g. subframe or OFDM symbol) where paging DCI can be sent (TS 38.213 [4]). One Paging Frame (PF) is one Radio Frame and may contain one or multiple PO(s) or starting point of a PO.

In multi-beam operations, the UE assumes that the same paging message and the same Short Message are repeated in all transmitted beams and thus the selection of the beam(s) for the reception of the paging message and Short Message is up to UE implementation. The paging message is same for both RAN initiated paging and CN initiated paging.

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

The PF and PO for paging are determined by the following formulae:

SFN for the PF is determined by:

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

Index (i\_s), indicating the index of the PO is determined by:

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

The PDCCH monitoring occasions for paging are determined according to *pagingSearchSpace* as specified in TS 38.213 [4] and *firstPDCCH-MonitoringOccasionOfPO* and *nrofPDCCH-MonitoringOccasionPerSSB-InPO* ifconfigured as specified in TS 38.331 [3]. When *SearchSpaceId* = 0 is configured for *pagingSearchSpace*, the PDCCH monitoring occasions for paging are same as for RMSI as defined in clause 13 in TS 38.213 [4].

When *SearchSpaceId* = 0 is configured for *pagingSearchSpace*, Ns is either 1 or 2. For Ns = 1, there is only one PO which starts from the first PDCCH monitoring occasion for paging in the PF. For Ns = 2, PO is either in the first half frame (i\_s = 0) or the second half frame (i\_s = 1) of the PF.

When *SearchSpaceId* other than 0 is configured for *pagingSearchSpace,* the UE monitors the (i\_s + 1)th PO. A PO is a set of 'S\*X ' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1* and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPO* if configured or is equal to 1 otherwise. The [x\*S+K]th PDCCH monitoring occasion for paging in the PO corresponds to the Kth transmitted SSB, where x=0,1,…,X-1, K=1,2,…,S. The PDCCH monitoring occasions for paging which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for paging in the PF. When *firstPDCCH-MonitoringOccasionOfPO* is present, the starting PDCCH monitoring occasion number of (i\_s + 1)th PO is the (i\_s + 1)th value of the *firstPDCCH-MonitoringOccasionOfPO* parameter; otherwise, it is equal to i\_s \* S\*X. If X > 1, when the UE detects a PDCCH transmission addressed to P-RNTI within its PO, the UE is not required to monitor the subsequent PDCCH monitoring occasions for this PO.

NOTE 1: A PO associated with a PF may start in the PF or after the PF.

NOTE 2: The PDCCH monitoring occasions for a PO can span multiple radio frames. When *SearchSpaceId* other than 0 is configured for *paging-SearchSpace* the PDCCH monitoring occasions for a PO can span multiple periods of the paging search space.

The following parameters are used for the calculation of PF and i\_s above:

T: DRX cycle of the UE (T is determined by the shortest of the UE specific DRX value(s), if configured by RRC and/or upper layers, and a default DRX value broadcast in system information. In RRC\_IDLE state, if UE specific DRX is not configured by upper layers, the default value is applied).

N: number of total paging frames in T

Ns: number of paging occasions for a PF

PF\_offset: offset used for PF determination

UE\_ID: 5G-S-TMSI mod 1024

Parameters *Ns*, *nAndPagingFrameOffset*, *nrofPDCCH-MonitoringOccasionPerSSB-InPO*, and the length of default DRX Cycle are signaled in *SIB1*. The values of N and PF\_offset are derived from the parameter *nAndPagingFrameOffset* as defined in TS 38.331 [3]. The parameter *first-PDCCH-MonitoringOccasionOfPO* is signalled in *SIB1* for paging in initial DL BWP.For paging in a DL BWP other than the initial DL BWP, the parameter *first-PDCCH-MonitoringOccasionOfPO* is signaled in the corresponding BWP configuration.

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.

5G-S-TMSI is a 48 bit long bit string as defined in TS 23.501 [10]. 5G-S-TMSI shall in the formulae above be interpreted as a binary number where the left most bit represents the most significant bit.

7.x PEI

7.x.1 PEI reception

The UE may use PEI in RRC\_IDLE and RRC\_INACTIVE states in order to reduce power consumption. If PEI configuration is provided in system information, the UE in RRC\_IDLE or RRC\_INACTIVE state supporting PEI (except for the UEs expecting multicast session activation notification) can monitor PEI using PEI parameters in system information according to the procedure described below.

If *lastUsedCellOnly* is configured in system information of a cell, the UE monitors PEI only in the cell if the UE most recently entered RRC\_IDLE or RRC\_INACTIVE states in this cell. Otherwise, the UE monitors PEI in the camped cell regardless of which cell the UE most recently entered RRC\_IDLE or RRC\_INACTIVE states.

The UE monitors one PEI occasion per DRX cycle. A PEI occasion (PEI-O) is a set of PDCCH monitoring occasions (MOs) and can consist of multiple time slots (e.g. subframe or OFDM symbol) where PEI can be sent (TS 38.213 [4]).

The time location of PEI-O for UE's PO is determined by a reference point and an offset from the reference point to the start of the first PDCCH monitoring occasion of this PEI-O:

* The reference point is the start of a reference frame determined by a frame-level offset from the start of the first PF of the PF(s) associated with the PEI-O, provided by *PEI-F\_offset* in SIB1;
* The offset is a symbol-level offset from the reference point to the start of the first PDCCH MO of PEI-O, provided by *firstPDCCH-MonitoringOccasionOfPEI-O* in SIB1.

If one PEI-O is associated with POs of two PFs, the two PFs are consecutive PFs calculated by the parameters *PF\_offset*, *T*, *Ns*, and *N*. The first PF of the PFs associated with the PEI-O is provided by ((SFN for PF) - floor (*iPO*/*Ns*)\**T*/*N*, where SFN for PF is determined in clause 7.1, *iPO* = ((UE\_ID mod *N*) \* *Ns* + *i\_s*) mod *po-NumPerPEI*, and *po-NumPerPEI* is configured via SIB, *T*, *Ns*, and *N* are determined in clause 7.1.

The PDCCH monitoring occasions for PEI are determined according to *pei-SearchSpace* as specified in TS 38.213 [4], *PEI-F\_offset*, *firstPDCCH-MonitoringOccasionOfPEI-O* and *nrofPDCCH-MonitoringOccasionPerSSB-InPO* ifconfigured as specified in TS 38.331 [3]. When *SearchSpaceId* = 0 is configured for *pei-SearchSpace*, the PDCCH monitoring occasions for PEI are same as for RMSI as defined in clause 13 in TS 38.213 [4]. UE determines first PDCCH MO for PEI-O based on *PEI-F\_offset* and *firstPDCCH-MonitoringOccasionOfPEI-O*, as for the case with *SearchSpaceId* > 0 configured.

When *SearchSpaceId* = 0 is configured for *peiSearchSpac*, the UE monitors the PEI-O according to *searchSpaceZero*. When *SearchSpaceId* other than 0 is configured for *peiSearchSpace,* the UE monitors the PEI-O according to the *SearchSpace* of the configured *SearchSpaceId*.

A PEI occasion is a set of 'S\*X' consecutive PDCCH monitoring occasions, where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1*, and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPO* if configured or is equal to 1 otherwise. The [x\*S+K]thPDCCH monitoring occasion for PEI in the PEI occasion corresponds to the Kth transmitted SSB, where x=0,1,…,X-1, K=1,2,…,S. The PDCCH monitoring occasions for PEI which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for PEI in the PEI-O. When the UE detects a PEI within its PEI-O, the UE is not required to monitor the subsequent monitoring occasion(s) associated with the same PEI-O.

If the UE detects PEI and the PEI indicates the subgroup the UE belongs to to monitor the associated PO, as specified in clause 10.4a in TS 38.213 [4], the UE monitors the associated PO as specified in clause 7.1. If the UE does not detect PEI on the monitored PEI occasion or the PEI does not indicate the subgroup the UE belongs to to monitor the associated PO, as specified in clause 10.4a in TS 38.213 [4], the UE is not required to monitor the associated PO as specified in clause 7.1.

If the UE is unable to monitor the PEI occasion (i.e. all valid PDCCH monitoring occasion for PEI) corresponding to its PO, e.g. during cell re-selection, the UE monitors the associated PO according to clause 7.1.

7.y Subgrouping

7.y.0 General

If PEI and subgrouping are configured, UEs monitoring the same PO can be divided into one or more subgroups. With subgrouping, the UE monitors PO if the corresponding bit for subgroup the UE belongs to is indicated as 1 by PEI corresponding to its PO, as specified in clause 10.4a in TS 38.213 [4]. UE's subgroup can be either assigned by CN as specified in clause 7.y.1 or formed based on UE\_ID as specified in clause 7.y.2:

- If *subgroupsNumForUEID* is absent in *subgroupConfig*, the subgroup ID based on CN assigned subgrouping as specified in clause 7.y.1 is used in the cell.

- If both *subgroupsNumPerPO* and *subgroupsNumForUEID* are configured, and *subgroupsNumForUEID* has the same value as *subgroupsNumPerPO*, the subgroup ID based on UE\_ID based subgrouping as specified in clause 7.y.2 is used in the cell.

- If both *subgroupsNumPerPO* and *subgroupsNumForUEID* are configured, and *subgroupsNumForUEID* < *subgroupsNumPerPO*, the subgroup ID based on CN assigned subgrouping as specified in clause 7.y.1, if available for the UE, is used in the cell; otherwise, the subgroup ID based on UE\_ID based subgrouping as specified in clause 7.y.2 is used in the cell.

The following parameters are used for the determination of subgroup ID:

subgroupsNumPerPO: number of subgroups for total CN assigned subgrouping (if any) and UE\_ID based subgrouping (if any) in a PO, which is broadcasted in system information

subgroupsNumForUEID: number of subgroups for UE\_ID based subgrouping in a PO, which is broadcasted in system information

If a UE has no CN assigned subgroup ID or does not support CN-assigned subgrouping, and there is no configuration for *subgroupsNumForUEID*, the UE monitors paging in its associated PO as specified in clause 7.1.

7.y.1 CN assigned subgrouping

Paging with CN assigned subgrouping is used in the cell which supports CN assigned subgrouping, as described in clause 7.y.0. A UE supporting CN assigned subgrouping in RRC\_IDLE or RRC\_INACTIVE state can be assigned a subgroup ID (between 0 to 7) by AMF through NAS signalling. The UE belonging to the assigned subgroup ID monitors its associated PEI which indicates the paged subgroup(s) as specified in clause 7.x.

7.y.2 UE\_ID based subgrouping

Paging with UE\_ID based subgrouping is used in the cell which supports UE\_ID based subgrouping, as described in clause 7.y.0.

If the UE is not configured with a CN assigned subgroup ID, or if the UE configured with a CN assigned subgroup ID is in a cell supporting only UE\_ID based subgrouping, the subgroup ID of the UE is determined by below formula:

SubgroupID = (floor(UE\_ID/(N\*Ns)) mod subgroupsNumForUEID) + (subgroupsNumPerPO - subgroupsNumForUEID),

where:

N: number of total paging frames in T

Ns: number of paging occasions for a PF

UE\_ID: 5G-S-TMSI mod X, where X is 32768, if eDRX is applied; otherwise, X is 8192

subgroupsNumForUEID: number of subgroups for UE\_ID based subgrouping in a PO, which is broadcasted in system information

The UE belonging to the SubgroupID monitors its associated PEI which includes the paged subgroup(s) as specified in clause 7.x.

Next change

Z TRS

The UE in RRC\_IDLE and RRC\_INACTIVE state may use TRS whose configurations are provided in system information for its paging reception to save power. In a cell in which TRS are available for the UE in RRC\_IDLE and RRC\_INACTIVE states to use, the availability of configured TRS is informed to the RRC\_IDLE and RRC\_INATIVE state UEs based on explicit L1 based availability indication defined in TS 38.213 [4].

End of change