3GPP TSG-RAN WG2 Meeting #110 Tdoc R2-2005940

Online, June 1st – 12th 2020

Agenda: 7.2.3

Source: Ericsson (Summary rapporteur)

Title: [ATT110-e][313] PUR open issues – Phase 2

Document for: Discussion, Decision

# 1 Introduction

This document provides the summary of the wollowin email discussion:

* [AT110-e][313][NBIOT/eMTC] PUR open issues (Ericsson)

      Status: Started

      Scope: Finalise PUR open issues based on [R2-2005726](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_110-e/Docs/R2-2005726.zip)

      Intended outcome: Report in [R2-2005936](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_110-e/Docs/R2-2005936.zip), Phase 2 report in R2-2005940

      Deadline: phase 1 – June 2 16:00 UTC. Phase 2 – Friday 1000 UTC

Compared to Phase 1, discussion on TBS is removed as agreements have been reached. Regarding the LS discussion, a new question is added about the details of how to specify the working assumption of using the adjustment value to update configuration in RRC.

The following have been agreed during RAN2#110 on PUR:

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| **Agreements:**TB sizes:* Maximum value for *requestedTBS* for eMTC is b2984 and for NB-IoT b2536.
* For *requestedTBS,* use 64 values for eMTC and 32 values for NB-IoT.

RAN1 LSs:* Confirm the feasibility of RAN1 working assumption on search space priority, send a reply LS to RAN1.
* Working assumption: Update RRC with DCI adjustment on repetitions.
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Introduction from R2-2005726:

This document provides the summary of the following email discussion:

* [AT110-e][313][NBIOT/eMTC] PUR open issues (Ericsson)

      Status: Not Started

      Scope: Finalise PUR open issues based on [R2-2005726](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_110-e/Docs/R2-2005726.zip)

      Intended outcome: Report in R2-2005936

      Deadline: phase 1 – June 2 16:00 UTC

This version has tables for company inputs on top of the original version in R2-2005762.

Company inputs have been summarized and Rapporteur proposals are made to progress the discussion.

Original introduction from R2-2005726:

This document provides a summary of proposals and topics discussed in [1] - [13] for PUR.

The proposals from the submitted documents have been grouped per topic, summarized and rapporteur proposals are made for decision or further discussion.

The following RILs are discussed in this document: [E906, E907, H810, H811, H840, H841, H854].

The following was conclusion of PUR discussions during RAN2#109bis-e:

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| RAN2#109bis-e agreements:RRC:* For both NB-IoT and eMTC, the value range of pur-TimeAlignmentTimer-r16 is INTEGER (1..8), i.e. 1~8 \* PUR periodicity.
* All PUR parameters are stored in the eNB. RAN2 has not identified any parameters that must be stored in the MME.
* Revert the previous working assumption, PUR grant is maintained in RRC.
* The handling of ‘m’ counter is moved from MAC to RRC.
* For pur-Periodicity-r16 and requestedPeriodicity-r16, confirm that the value range is {hsf8, hsf16, hsf32, hsf64, hsf128, hsf256, hsf512, hsf1024, hsf2048, hsf4096, hsf8192, spare5, spare4, spare3, spare2, spare1} for both NB-IoT and eMTC.
* For both NB-IoT and eMTC, PUR request indicates requested start time/offset of PUR in H-SF level.
* FFS: 2-level offset need and details for pur-StartTime-r16.
* Requested PUR TBS values:
	+ - For the requested PUR TBS in eMTC and NB-IoT, the minimum value is b328.
		- FFS: other details.
* FFS: It is up to eNB implementation how to link CP-PUR configuration to each UE in RRC\_IDLE according to PUR resource.

MAC aspects:* Remove the Editor’s Note “FFS whether restarting the window is indended” from 36.321.
* Remove the Editor’s Note “FFS what is the impact of PUR in this section” from 36.321.

hRRC-MAC interactions:* No further MAC-RRC interaction on TA validation is needed. Remove the Editor’s Note “How RRC indicates to MAC that TA is valid or instructs MAC to use PUR” from 36.321.
* Remove the references to PUR TA timer validation in section 5.4.7.1 from 36.321.
* PUR release due to RACH initiation on a new cell is captured in RRC.
* PUR configuration is released when the UE initiates RA procedure on a new cell for all purposes.
* RRC configures the lower layers to use PUR grant upon initiation of transmission using PUR.
* FFS: implicitReleaseAfter handling and other RRC-MAC interaction details.

Other:* Confirm that transmission using PUR cannot be used for signalling, i.e. mt-Access and mo-Signalling cannot be used for transmission using PUR.
* From RAN2 point of view PUR (re-)configuration can be provided to the UE for the CP solution without AS security enabled.
	+ - No consensus to send an LS to SA3.
* PUR-RNTI is used as the name of RNTI used for PUR.
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# 2 Discussion

## 2.1 [H810, H840] PUR offset

Another issue left FFS in RAN2#109bis-e is how the PUR starting time is exactly configured. The UE may request an offset, and the NW configures the starting time in *pur-StartTime.*

The following are the proposals related to this topic:

* Working assumption on maximum PUR time offset is not confirmed. UE can request offset up to 1024 H-SFNs and eNB can configure pur-StartTime up to 1024 H-SFNs from the current time instant.[1] (Ericsson)
* For configuring pur-StartTime, adopt a structure with different levels to indicate H-SFN, SFN and SF.[1] (Ericsson)
* UE can request the time offset on H-SFN level.[1] (Ericsson) **[Rap: Agreed already in RAN2#109bis-e]**
* Further discuss what level of granularity is used for different levels for request of the PUR offset and the configuration of pur-StartTime.[1] (Ericsson)
* For both NB-IoT and eMTC, the value range of pur-StartTime is INTEGER (0..81919). The value is in number of sub-frames by step of (pur-Periodicity / 8).[4] (Huawei, HiSilicon)
* For both NB-IoT and eMTC, the value range of requestedTimeOffset is {hsf8, hsf16, hsf32, hsf64, hsf128, hsf256, hsf512, hsf1024, hsf2048, hsf4096, hsf8192, spare5, spare4, spare3, spare2, spare1}.[4] (Huawei, HiSilicon)
* It’s suggested to agree the following definition for pur-StartTime-r16:[9] (ZTE Corporation, Sanechips)

pur-PeriodAndStartTime-NB-r16 ::= SEQUENCE {

offsetHSF ::= CHOICE {

 offsetWithinPeriodHsf128 INTEGER (0..127),

 offsetWithinPeriodHsf256 INTEGER (0..255),

 offsetWithinPeriodHsf512 INTEGER (0..511),

 offsetWithinPeriodHsf1024 INTEGER (0..1023),

 offsetWithinPeriodHsf2048 INTEGER (0..2047),

 offsetWithinPeriodHsf4096 INTEGER (0..4095),

 offsetWithinPeriodHsf8192 INTEGER (0..8191),

},

offsetSubframe INTEGER (0..1023)

} OPTIONAL, --Need ON

* Confirm that level-1 information regarding PUR start time is an offset relative to a reference H-SFN.[10] (Qualcomm Incorporated)
* The reference H-SFN is the H-SFN corresponding to the subframe of the last PDSCH repetition for the first transmission of the RRC release message including the PUR (re)configuration.[10] (Qualcomm Incorporated)
* LSB of the reference H-SFN is included in the PUR (re)configuration message.[10] (Qualcomm Incorporated)

**Reference H-SFN for start time**

Only [10] contains a proposal regarding the reference time and whether the offset should be relative or absolute time instead. [1] and [9] also mention time reference but provide no explicit proposals. However, there seems to be common understanding on that the offset should be relative to the time of configuration. [10] further proposes to fix the reference H-SFN to last PDSCH repetition of the RRC release message transmission, and to provide 1-bit LSB information to avoid potential misalignment between UE and the eNB regarding the reference H-SFN.

The reference as suggested in [10] can be the starting point of the discussion and as the proposals are new, RAN2 should further discuss whether additional clarifications are needed for proper alignment between eNB and UE:

1. Confirm that PUR starting time configuration in *pur-StartTime* is an offset relative to a reference H-SFN.
2. *pur-StartTime* reference is the H-SFN corresponding to the last subframe of the first transmission of RRC release message containing *pur-Config.*
3. Discuss whether alignment of the reference H-SFN between eNB and UE requires further clarification.

Q2: Do you support Proposals 3 and/or 4, i.e. relative offset to a reference H-SFN, or would you prefer configuration using absolute value instead? If you support relative offset, do you further think H-SFN alignment requires further clarification?

Note this question can be related to Proposals 7 and 8 below especially on deciding relative vs. absolute configuration.

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| Company | Preference | Comments |
| Thales | Support 3,4 | Pur-StartTime based on reference H-SFN i.e. as relative reference to RRC release message providing the configuration should be fine. |
| Huawei, HiSilicon | P3 and P4 | Relative vs. Absolute offset depends on the maximum value of the start offset. If the maximum value for the start offset is larger than 1024 HSFN in NB-IoT (256 HSFN in eMTC), we think relative offset is better to avoid misalignment issue.According to our reply to Q4, we prefer relative offset. |
| ZTE | relative offset | Per our understanding, PUR start time would be possible at any time during the configured PUR periodicity. As the UE can only send PUR request during RRC\_CONNECTED, if the requested H-SFN offset is not so large while the connection lasts a little long, it may be possible for the network to miss the first requested PUR occasion and have to assign PUR grant around the next requested PUR occasion. The next requested PUR occasion may be far away from the time of provision of PUR configuration, especially in the case of large PUR periodicity. Therefore, we think it must allow the configured H-SFN to be beyond one full H-SFN cycle (1024 H-SFNs), e.g., the maximum configured H-SFN offset would be allowed to be same as maximum PUR periodicity.As mentioned in [10], if it’s allowed the configured H-SFN to be beyond one full H-SFN cycle and considering the H-SFN can wrap around one or more times before the first PUR occasion, the absolute H-SFN for start time would be not enough for UE to calculate the first PUR occasion as it cannot know how many H-SFN wrap arounds needs to be skipped. So we think absolute H-SFN is not feasible.In a summary, we are fine with the proposal 3 and proposal 4.For the issue of relative offset mentioned in [10], even we think it may be mainly for some rare case, e.g., the transmission of RRC release message in eNB is at the boundary of a H-SFN and then the transmission at eNB and successfully reception of RRC release message at UE are just in the different H-SFNs, we still agree it needs to be resolved. We are fine with the related proposal in [10], e.g., 1-bit LSB of the reference H-SFN is included in the PUR (re)configuration message. |
| LG | Relative | We support P3 and P4 |
| Ericsson | Absolute, but conditional on P7/Q4. | If we agree to revert the working assumption on maximum offset, then absolute reference to H-SFN can be easily used and it shouldn't have issues with syncronization. Otherwise, with full offset range up to PUR periodicity (i.e. longer than one full cycle of H-SFNs) it should be relative offset and then we should discuss what is the definition of reference H-SFN, in general P4 seems fine. On P5, we are not convinced that a further clarification is needed, we can further discuss this.  |
| Qualcomm | Not strong view amongEither: relative + H-SFN alignment, Or:Absolute H-SFN. | Basically repeating the same comment provided earlier by email:Essentially proposal 3 and 5 above are related. Only when the alignment of the reference H-SFN between the eNB and UE can be guaranteed, a “relative” H-SFN offset wrt reference H-SFN would work; otherwise “absolute” H-SFN value (note, this should not to be confused as absolute timestamp) for the start time would be needed (and in that case proposal 4 would not be needed).And that is further related to the following proposals: Proposal 7           Discuss whether working assumption: "Maximum PUR time offset should be the same as maximum PUR periodicity" is confirmed. Proposal 8           Discuss and choose the value range and code points for H-SFN in pur-StartTime. That is because if the working assumption is confirmed, clarification/handling would be needed on what the indicated value of the H-SFN means when it is indicated to be beyond one cycle of 1024 H-SFN. On the other hand if the max time offset is restricted within say a full H-SFN warp around cycle ~2.9 hr by reverting the working assumption, then a simple indication of INTEGER (0..1023) could be sufficient to indicate the start H-SFN in “absolute” scale, assuming the network configures PUR sufficiently in advance such that there is no possibility for the problem due to H-SFN increment as illustrated in [10] to occur (e.g. absolute H-SFN for start time = 20 would likely be fine if the first DL for the configuration is being started as late as during H-SFN = 18, just as an example). However, the disadvantage of reverting the working agreement is losing the ability to support use cases such as a UE would not be able to send say the first report during RRC connected and ask for PUR during the same connection for further reports occurring periodically where period is > 3hr, or a UE requesting PUR after the power-up and registration, but needing to go to connected again sometime before the first transmission to ask for PUR at that time. So, there is a tradeoff here. (Note we do not think “implementation” or “time synchronization” are valid concerns to revert the working assumption because with that logic, even the periodicity of PUR would not be possible beyond 1024 H-SFN, but RAN2 has agreed up to 8192 H-SFN periodicity.) |
| ASUSTeK | Support P3 & P4 | Absolute offset may not be suitable considering the large periodicity of PUR. |
| Nokia | Relative offset | P3 is preferred. OK for P4 also. |

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| **Summary for Q2:**8 replies where 6 replies support P3 and P4 and assume relative offset, given that the offset value range is larger than 1024 H-SFN. 1 company supports offset range of up to 1024 H-SFN and assuming that, absolute value, otherwise relative offset. 1 company is fine either way. Proposals are suggested below after question related to original P7 and P8.  |

Parameter *pur-StartTime*

On the *pur-StartTime* structure, the following options have been brought up as examples and in proposals in the submitted contributions and/or proposals:

In [1]:

pur-StartTime-r16 ::= SEQUENCE {

 pur-startHSFN-r16 ENUMERATED {0, 256, 512, 768},

 pur-startSFN-r16 INTEGER {0..1023},

 pur-startSubframe-r16 INTEGER {0..9}

}

In [4]:

 pur-StartTime-r16 INTEGER (0..81919)

 OPTIONAL, --Need ON

 pur-Periodicity-r16 ENUMERATED {hsf8, hsf16, hsf32, hsf64, hsf128, hsf256,

 hsf512, hsf1024, hsf2048, hsf4096, hsf8192,

 spare5, spare4, spare3, spare2, spare1}

| *PUR-Config(*-*NB)* field descriptions |
| --- |
| ***pur-StartTime***Indicates the value of the time offset for the first PUR occasion, i.e. the time gap from reception of D-PUR configuration to the first PUR occasion. Value is in number of sub-frames by step of (*pur-Periodicity* / 8). |

The corresponding proposal:

* For both NB-IoT and eMTC, the value range of pur-StartTime is INTEGER (0..81919). The value is in number of sub-frames by step of (pur-Periodicity / 8). [4] (Huawei, HiSilicon)

And in [9]:

pur-PeriodAndStartTime-NB-r16 ::= SEQUENCE {

offsetHSF ::= CHOICE {

 offsetWithinPeriodHsf128 INTEGER (0..127),

 offsetWithinPeriodHsf256 INTEGER (0..255),

 offsetWithinPeriodHsf512 INTEGER (0..511),

 offsetWithinPeriodHsf1024 INTEGER (0..1023),

 offsetWithinPeriodHsf2048 INTEGER (0..2047),

 offsetWithinPeriodHsf4096 INTEGER (0..4095),

 offsetWithinPeriodHsf8192 INTEGER (0..8191),

},

offsetSubframe INTEGER (0..1023)

} OPTIONAL, --Need ON

The structures are different, but all have in common multiple (2 or 3) levels and that the highest level is H-SFN level and lowest level is subframe level. One example additionally has a separate level for SFN. The key issue is what granularity should be specified at each level vs. the size of the configuration in bits. In particular, it should be decided whether all or any H-SFN can be indicated within maximum range and whether all or any subframe within higher level step size can be indicated.

1. Adopt a multi-level structure for *pur-StartTime.* Highest level indicates H-SFN and lowest level indicates subframe. FFS whether SFN level is needed.

Q3: Do you support Proposal 6?

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| Company | Yes / no | Comments |
| Thales | Yes | However, first transmission according to PUR should be done at **PUR-periodicity+ pur-StartTime**. UE is in dedicated negotiating PUR configuration. For power saving reasons it also provides information it wants to transmit in one go, hence next information is available in PUR-periodicity so PUR start Time should start at D-PUR periodicity+pur-StartTime. (R2-2000250 fig. 1) Example Ue has periodicity hsf64 (about 11 minutes), requested and provides in said dedicated session already the data to the server. So for the next hsf64 it has nothing to transmit (data are generated/provided only once every 11 minutes), so starting PUR should be interpreted as D-PUR periodicity+pur-StartTime.  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes | Per our understanding, the pur-StartTime is used to calculate the first PUR occasion. We are not clear why it’s D-PUR periodicity+pur-StartTime? This should be for the following PUR occasions, not the first PUR occasion. Moreover, as mentioned by rapporteur, in our proposal [9], the value range for *offsetSubframe* is incorrect. We confirm it should be any subframe covered by one H-SFN. So the maximum value should be 1024\*10-1 = 10239, e.g., as following:offsetSubframe-r16 INTEGER {0..10239}With the correction, we think such integrated definition for radio frame /subframe is almost same as the following proposal in [1], e.g., with same value range and requests same 14 bits signalling:pur-startSFN-r16 INTEGER {0..1023},pur-startSubframe-r16 INTEGER {0..9}We are fine with above either way for radio frame/subframe definition.For proposed way in [4], we still concern the possible large interval between the allowed subframe offset, especially in the case of large PUR periodicity.  |
| LG | Yes |  |
| Ericsson | Yes | We also don't understand why the first occasion should be at periodicity + startTime?  |
| Qualcomm | Yes | If the requested offset is limited within ~2.9 hr/ one H-SFN cycle (i.e. revert WA): Three level: H-SFN (absolute), SFN within the H-SFN, and subframe within the SFN:pur-StartTime-r16 ::= SEQUENCE { pur-startHSFN-r16 INTEGER (0..1023), pur-startSFN-r16 INTEGER (0..1023), pur-startSubframe-r16 INTEGER (0..9)}Additionally if more than one H-SFN (i.e. keep WA) one more info is required:pur-StartTime-r16 ::= SEQUENCE { pur-skipHSFN-Cycles-r16 INTEGER (0..7), pur-startHSFN-r16 INTEGER (0..1023), pur-startSFN-r16 INTEGER (0..1023), pur-startSubframe-r16 INTEGER (0..9)} |
| ASUSTeK | Yes |  |
| Nokia | Yes |  |

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| **Summary for Q3:**8 replies where all companies support adopting a multi-level structure. The exact details can be worked out when all agreements on range and values are in place – see proposal Q5.  |

There is a working assumption on that PUR time offset has the same range as maximum PUR periodicity. However, in [1] it is argued and proposed that there should be no need for longer offsets than e.g. 1024 H-SFNs. No other papers explicitly mention this working assumption but this seems to be implicitly assumed in other proposals e.g. in [4] and [9]. The following proposals can be discussed together, i.e. what should be the range and how many code points should be supported – the full range e.g. like in [9] or some other set like in [1] or [4]:

1. Discuss whether working assumption: "Maximum PUR time offset should be the same as maximum PUR periodicity" is confirmed.
2. Discuss and choose the value range and code points for H-SFN in *pur-StartTime.*

Q4: Should RAN2 confirm working assumption: "Maximum PUR time offset should be the same as maximum PUR periodicity" (Proposal 7)? Please elaborate what value range and code points should be adopted for H-SFN in *pur-StartTime* (Proposal 8).

Note that it might be beneficial to discuss P7 before P3,4,5 above.

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| Company | Confirm WA (P7)? | What value range should be adopted (P8)?  |
| Thales | Yes/No | Range of one maximum PUR offset being one D-PUR periodicity is fine but it needs to last from maximum PUR periodicity to 2x maximum PUR periodicity. |
| Huawei, HiSilicon | Yes | It is proposed in [1] that the maximum value should be smaller than 1024 HSF (about 3 hours). This is based on the assumption that the UE can request PUR within 3 hours before it wants to use PUR. However, we are not sure this is feasible as 1) the UE cannot establish RRC connection only for PUR request. 2) the eNB may configure PUR to the UE without PUR request.Thus we think the working assumption makes sense and should be confirmed.For the values of the HSFN level offset, we think (0..8191) (13bits) can be baseline. If we want to optimise the signaling overhead, similar way as we used for C-DRX offset in NB-IoT can be considered (proposal in [4]) |
| ZTE | Yes | As mentioned in our comments for Q2, we understand PUR time offset should be configured according to PUR periodicity, and Maximum PUR time offset can be the same as maximum PUR periodicity. Therefore, we suggest the following joint definition for PUR periodicity and offset H-SFN:offsetHSF ::= CHOICE { offsetWithinPeriodHsf128 INTEGER (0..127), offsetWithinPeriodHsf256 INTEGER (0..255), offsetWithinPeriodHsf512 INTEGER (0..511), offsetWithinPeriodHsf1024 INTEGER (0..1023), offsetWithinPeriodHsf2048 INTEGER (0..2047), offsetWithinPeriodHsf4096 INTEGER (0..4095), offsetWithinPeriodHsf8192 INTEGER (0..8191),} |
| LG | Yes |  |
| Ericsson | No | We think range of up to one full range of H-SFN (up to 1024 H-SFN) should be more than enough and would provide opportunity to request configuration up to 2.9 hours earlier. We would be fine with even shorter range. As additional benefit, in this case we could directly indicate the absolute starting H-SFN using values 0-1023 as indicated in SI (See Q2 above).We don't understand why UE couldn't establish RRC connection for PUR request (see HW reply), especially as we have the following agreement: * UE is not restricted from initiating RRC Connection for the purpose of sending PUR request (i.e. this agreement has no impact to legacy RRC Connection Establishment / Resume procedures).
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| Qualcomm | - | See comments above. No strong view on whether to confirm or revert the WA. But the other solutions depend on the conclusion here. So, it is better to discuss and conclude this first.In either case, each H-SFN should be possible to be referred to as shown in ASN.1 example in above comment. |
| ASUSTeK | No | For relative offset, up to 1024 H-SFN should be enough. |
| Nokia | Yes | It is reasonable to have the range for offset is aligned with periodicity for better distribution of grants for UE having same periodicity. |

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| **Summary for Q4:**8 replies where 4 companies indicate clear 'yes' and 2 companies a clear 'no'. One company replies 'yes/no' but based on comments they seem to think the offset should be larger than maximum periodicity. One company is fine either way. Based on the replies there seems to be more support for longer offset than 1024 H-SFN, however it seems clarifications would be best discussed further online, therefore:**Rapporteur proposal Q4: Discuss further whether the working assumption on requested offset should be confirmed or not.**The proposal related to above Q2 and original P3, P4, P5 depend on the outcome of the discussion.Proposals conditional on confirming the working assumption:The next two proposals are the original P3 and P4 which were supported by majority in Q2:**Rapporteur proposal Q4a: Confirm that PUR starting time configuration in *pur-StartTime* is an offset relative to a reference H-SFN.** **Rapporteur proposal Q4b: *pur-StartTime* reference is the H-SFN corresponding to the last subframe of the first transmission of RRC release message containing *pur-Config*.** The alignment issue was not discussed in detail in many of the replies thus needs to be discussed and decided further:**Rapporteur proposal Q4c: Discuss further whether the working assumption on requested offset should be confirmed or not.**Proposals conditional on reverting the working assumption:If the working assumption on maximum offset is reverted and e.g. the H-SFN is indicated in existing signalling, then it is proposed to adopt absolute indication of H-SFN instead**Rapporteur proposal Q4d: H-SFN level is indicated in absolute terms, i.e. the configuration indicates the starting H-SFN according to signaled H-SFN value.** |

For the subframe level, different approaches are brought up in [1] [4] [9]: Full range of subframes within H-SFN, a sparser set of subframes e.g. every second/fourth or similar, and sparser set based on a function depending on *pur-Periodicity*. One paper additionally proposes to use SFN level with further discussion needed for granularity.

1. Discuss and choose the value range and code points for subframe level (and SFN level, if needed) in *pur-StartTime.*

Q5: Input to Proposal 9:

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| Company | Comments (value range for SF level, need for SFN level?) |
| Thales | From UE perspective intending to provide its data once very D-PUR periodicity a a Pur-StartTime being function of the D-PUR periodicity, every n-th subframe would be fine.  |
| Huawei, HiSilicon | Same comments as above, the following can be baseline to cover all possilbe HSFN/SFN/subframes:* HSF (0..8191) 13bits
* SFN (0..1023) 10bits
* Subframe (0..9) 4bits

If we want to optimise the overall signaling overhead for the start offset, similar way as we used for C-DRX offset in NB-IoT can be considered (proposal in [4]) |
| ZTE | As mentioned in the comments for Q3, we are fine with following either way for offset subframe definition:offsetSubframe-r16 INTEGER {0..10239}orpur-startSFN-r16 INTEGER {0..1023},pur-startSubframe-r16 INTEGER {0..9}Moreover, we think clarification for the start point for this offsetSubframe (e.g. kind of reference subframe) is needed. A simple way may be to set the subframe #0 of the first radio frame in the start H-SFN (start H-SFN = reference H-SFN + offset H-SFN) as the reference subframe. The final start subframe would be equal to “reference subframe + offsetSubframe“. |
| Ericsson | For examplepur-StartTime-r16 ::= SEQUENCE { pur-startHSFN-r16 ENUMERATED {0, 256, 512, 768}, pur-startSFN-r16 INTEGER {0..1023}, pur-startSubframe-r16 INTEGER {0..9}}We can further discuss the granularity and code points on each level. Also, depending on the details SFN level might not be needed.  |
| Qualcomm | For network flexibility, we think both SFN and subframe levels are needed, and each of the possible SFN or subframe should be possible to be configured as shown in ASN.1 example shown above.However, it is possible to reduce number of bits by allowing PUR scheduling only certain SFN or subframes (or having only on subframe #X and not signaling it). But to us, the cost of extra bits is worth it for scheduling flexibility. (In any case, quickly looking at examples above, Huawei proposes to use 17 bits and ZTE’s TP uses at least 24 bits, or more depending on which choice value is used. The above ASN.1 uses 24 bits.) |
| ASUSTeK | subframe: 0~9 (4-bit), SFN: 0~1023 (10-bit) |
| Nokia | OK with the structure proposed by Ericsson |
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Based on the outcome of the discussion, the final structure can be specified in TS 36.331.

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| **Summary of Q5:**7 replies where majority of companies seem to prefer baseline of separate H-SFN, SFN and SF ranges. No strong opinions on possible optimizations are brough up, therefore full ranges are proposed as baseline:**Rapporteur proposal Q5: Following structure is adopted as baseline for *pur-StartTime*:**pur-StartTime-r16 ::= SEQUENCE { pur-startHSFN-r16 INTEGER (0..1023) OR INTEGER (0..8191), pur-startSFN-r16 INTEGER (0..1023), pur-startSubframe-r16 INTEGER (0..9)}Possible optimizations of above and whether there is need e.g. for additional H-SFN cycle level can be discussed further.  |

**Requested offset**

It has been agreed earlier that the requested offset is done on H-SFN level. It seems reasonable and is discussed or implicitly assumed in the papers the configuration can be the same as the highest (H-SFN) level of the *pur-StartTime* configuration.

1. Requested offset has the same range as the agreed H-SFN level of *pur-StartTime.*

**Q6: Do you support Proposal 10?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / no | Comments |
| Thales | Yes | Requested offset can have same range as pur-StartTime+PUR-periodicity, in case UE has as provided its data in the connection session negotiating the PUR |
| Huawei, HiSilicon | Conditional yes | If we go with HSFN (0..8191) for pur-StartTime, 13 bits is too big signaling overhead from request perspective. |
| ZTE | Yes | UE is allowed to request offset according to the requested PUR-periodicity. |
| Ericsson  | Yes |  |
| Qualcomm | - | It just needs to be within H-SFN level, and same as maximum H-SFN value range that can be signaled in configuration.  |
| ASUSTeK | Yes |  |
| Nokia | - | No strong views. It is suggested offset. Network decides on the actual value based on resource allocation for different PUR UE. Needs to be within H-SFN level.  |
|  |  |  |

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| --- |
| **Summary of Q6:**7 replies, where 4 companies reply yes, one company conditional yes depending on the exact values for H-SFN level configuration, one company doens't have a direct reply but comments it needs to be in H-SFN level (which is already agreed) and one company has no strong view. Proposal at this stage is revisit this discussion once H-SFN level configuration in *pur-StartTime* has been discussed and decided.**Rapporteur proposal Q6: Revisit discussion on requested offset range once H-SFN level in *pur-StartTime* has been decided.** |

## 2.2 CP configuration

The following have been proposed related to the open issue on how eNB should link UE and its CP-PUR configuration:

* It is up to eNB implementation how UE and PUR configuration are linked together in RRC\_IDLE.[1] (Ericsson)
* UEs configured with CP-PUR can send PUR request message, e.g. to request a change or release PUR configuration, only by establishing RRC connection using its PUR occasion.[1] (Ericsson)
* UEs configured with CP-PUR do not count skipped 'm' in RRC\_CONNECTED only when they have used a PUR occasion to establish the RRC connection. Otherwise, when RRC connection is established using any other resources, skipped 'm' are counted also in RRC\_CONNECTED.[1] (Ericsson)
* It is up to eNB implementation how to link PUR configuration to each UE according to PUR resources.[3] (ITL)
* It’s suggested RAN2 to agree that eNB links CP-PUR configuration to each UE according to PUR resource by implementation.[9] (ZTE Corporation, Sanechips)
* It’s suggested RAN2 to discuss and agree that UE needs to send its PUR grant info (e.g. pur-StartTime, ul-CarrierFreq, npusch-CyclicShift) to eNB when UE enters into RRC\_CONNECTED.[9] (ZTE Corporation, Sanechips)

In the submitted papers and based on the discussions during the previous meeting, most if not all companies seem to now agree that it should be up to eNB how to link the UE and the CP-PUR configuration, i.e., it is not tied to any particular identifier. All papers [1], [3] and [9] mention the eNB can link the resource according to the used PUR resources.

1. It is up to eNB implementation how UE and PUR configuration are linked according to the configured PUR resources.

Q7: Do you support Proposal 11?

|  |  |  |
| --- | --- | --- |
| Company | Yes / no | Comments |
| Thales | Yes |  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes |  |
| LG | Yes |  |
| Ericsson | Yes |  |
| Qualcomm | Yes | In principle yes, but eNB needs further information to be able to do it as clearly explained by ZTE in their paper. |
| ASUSTeK | Yes |  |
| Nokia  | Yes |  |

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| --- |
| **Summary of Q7:**8 replies, where all companies reply yes. Issues have been brought up but it is assumed RAN2 is able to solve such issues in one way or another**Rapporteur proposal Q7: It is up to eNB implementation how UE and PUR configuration are linked according to the configured PUR resources.** |

It is further discussed in [1] and [9] that eNB might not be able to link UE to possible PUR configuration when it is in RRC\_CONNECTED, if the UE established RRC connection using other resources than those configured for PUR. This means PUR couldn't be reconfigured or released if eNB would not be able to link the UE and PUR configuration, and 'm' couldn't be counted properly (per current agreements, 'm' should not be counted while UE is in RRC\_CONNECTED if the PUR occasion is not used). To solve these issues:

* [1] proposes that PUR can be reconfigured or released only by using the configured PUR resources to establish RRC connection, and that 'm' would not be counted only when PUR resources were used to establish connection, but 'm' would be counted otherwise when other resources were used to establish the connection.
* [9] proposes UL grant information, i.e. the configured resources, are sent (back) to eNB when establishing RRC connection so the eNB can link the UE and its PUR configuration properly, and reconfiguration/release of PUR and 'm' counting would work properly in this case.

RAN2 should discuss whether these issues should be addressed and how:

1. For CP-PUR, RAN2 intends to address the case of reconfiguration/release and 'm' counting so that PUR works properly. FFS to choose between the proposed solutions.

Q8: Should RAN2 address the cases mentioned above (in [1], [9]) and in P12? If yes, what is the preferred mechanism?

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| --- | --- | --- |
| Company | Yes / no | Comments (e.g. preference and details of mechanism) |
| Thales | Yes | We would prefer mechanism outlined in [9] for CP-PUR, i.e. enable the eNB to link the UE and its PUR configuration properly so that reconfiguration and m count works accordingly/as agreed.  |
| Huawei, HiSilicon | Yes | Proposal in [1] adds restriction to the reconfiguration/release scenarios.Porposal in [9] will cause very big signaling overhead for the UE as the UE needs to send PUR configuration (more than 100 bits in NB-IoT, even larger in eMTC) to the eNB everytime it establishes RRC connection.If this issue needs to be addressed, we would like to suggest our previous proposal in R2-2000640 as an Option 3, i.e. storing pur-Config in a container in the MME. Upon receiving the Initial UE message including S-TMSI, the MME forwards the container with the PUR configuration, if any, to the eNB in the S1 DL NAS TRANSPORT message or S1 CONNECTION ESTABLISHMENT INDICATION message.In this case, the issue can be addressed without adding restriction to the reconfiguration/release scenarios and additional signaling overhead to the UE. |
| ZTE | Yes | If RAN2 would not address the cases mentioned above, it may cause misalignment between UE and eNB or even no response from eNB to UE's request.We think the proposed way in [1] would be too restricted for eNB or UE’s implementation. So we still prefer the proposed way in [9]. |
| LG | Yes | We support the solution in [1] to avoid complexity.  |
| Ericsson | Yes | As proposed in [1]: UE using CP PUR should request configuration change only when it has initiated the connection establishment using PUR resources.Change 'm' counting rules for RRC\_CONNECTED and for CP PUR so that 'm' is not counted only when UE established RRC connection using PUR resources. |
| Qualcomm | Yes | Proposal in [1] restricts the possibility to send PUR request when in CONNECTED mode and allows in only certain conditions which is not consistent with what has been agreed before. E.g. if the UE has a large UL data now, wants to go to connected and also ask for PUR release/reconfig which would otherwise be after 12 hours, that would be undue restriction to not allow to ask for release/reconfig now.Proposal in [9] Providing the Grant info back does not always solve the problem (e.g. shared grant). It needs further discussion on what parts need to be provided, e.g. maybe MCS does not make sense but time/frequency information need to be clear.Even from the principle point of view, better way is to send back the “identifier(s)” instead of “grant”. So, we think the following would solve the issue:* PUR-RNTI is mandatory in PUR-Config for configuration (can be delta signalled for reconfig).
* eNB can tag the PUR config with PUR-RNTI by implementation, given that sTMSI is not currently assumed to be stored by eNB, and that sTMSI might change from the time the UE first went to CONNECTED (regardless of with or without already having PUR Config) before the time PUR config is provided (which is done at the end of CONNECTED session with a release message).
* If network wants to share PUR-RNTI across different UEs, add another identifier, e.g. RNTI resolution identifer in the PUR-Config which can be a couple of bits depending on maximum how may UEs would share a same RNTI.
* UE includes PUR-RNTI (and the resolution ID if provided in config) in the PUR request message (for both config or release request). It is already clear the request message is always/only sent in CONNECTED.
 |
| Nokia |  | Agree with QC “UE should not be restricted to use only the messages sent over PUR resource for reconfiguration or release.Complete information of grant is not needed for the network to know the resource. Identifier with some additional information to uniquely identify the PUR is sufficient. |
| ZTE2 |  | Agree with above concerns for proposal in [1].Some clarification for proposal in [9]:* As PUR-RNTI share same RNTI space with other RNTIs, we assume not much PUR-RNTI can be allocated. The rate of PUR-RNTI being multiplexed by UEs may be high. Based on such consideration, if go for the QC’s suggestion, we think length for the additional new RNTI resolution identifer need to be long in order to differentiate more UEs. Moreover, this also looks like to introduce a “new PUR resource” dimension. Such “new PUR resource” also need to be (additionally) provided to the UE in the PUR configuration that will cause unnecessary signalling overhead.
* Per our understanding for physical layer spec, for the sake of uplink demodulation, the combination of time domain/frequency domain/code domain resources need to be unique for the UEs. So we believe it’s already feasible and more reliable to only use (part) of existing PUR resources as “identifier” to uniquely identify a UE. Then why new resource is needed?
* We disagree with HW’s concern on large number bits for such PUR resources “identifier”. The following is our assumption for NB-IoT and eMTC:

|  |
| --- |
| PUR resources “identifier” for NB-IoT (~total 63bits) |
| pur-StartTime-r16 (~at most 30 bits, can be smaller for shorter periodicity)ul-CarrierFreq-r16 (~25bits)npusch-SubCarrierSetIndex-r16 (~7bits)npusch-CyclicShift-r16 (~1bits) |

|  |
| --- |
| PUR resources “identifier” for eMTC (~total 43bits) |
| pur-StartTime-r16 (~at most 30 bits, can be smaller for shorter periodicity)pur-FreqInfo-r16 CHOICE { ce-ModeA SEQUENCE { prb-AllocationInfo-r16 BIT STRING (SIZE(10)) }, ce-ModeB SEQUENCE { prb-AllocationInfo-r16 BIT STRING (SIZE(8)), locationCE-ModeB-r16 INTEGER (0..5) } }  (~12 bits)pusch-CyclicShift-r16 (~1 bits) |

* One thing need to be clarify is that the definition for *pur-StartTime* in PUR resources “identifier” is similar as that *pur-StartTime* in *PUR-Config-r16*, but not totally same. The reference H-SFN for *pur-StartTime* in PUR resources “identifier” would be the H-SFN corresponding to the last subframe of the first transmission of Msg5.
* Moreover, we disagree with QC that such “identifier” can be provided via the PUR request message as this cannot handle the “m” counting issue.
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| **Summary of Q8:**7 replies, where all companies support the intention for resolve the issues brought up. Two companies explicitly support the way proposed in [1] and two companies prefer the way proposed in [9]. Of the three remaining companies, two have additional suggestions e.g. to store PUR configuration in MME which would be fetched using S-TMSI, or sending back the PUR-RNTI when establishing connection. One remaining company supports identifier with additional information. **Rapporteur proposal Q8a: For CP-PUR, RAN2 intends to address the case of reconfiguration/release and 'm' counting so that PUR works properly.****Rapporteur proposal Q8b: Discuss further which mechanism is adopted to address the issues mentioned in Proposal Q8a.**  |

## 2.3 [H854, E906, E907] MAC-RRC interaction

The following proposals have been submitted on other issues remaining in MAC or RRC or addressing MAC-RRC interaction issues:

* Capture calculation of Nth consecutive PUR occasion in TS 36.331 based on the provided example formula and the agreed structure and range of pur-StartTime.[1] (Ericsson)
* RRC provides pur-ResponseWindow size configuration to MAC when RRC configures lower layers for transmission using PUR.[1] (Ericsson)
* PUR-RNTI is explicitly configured when RRC configures lower layers for transmission using PUR.[1] (Ericsson)
* RRC provides the information of PUR timing in the form of UL grant to MAC layer in a way there is no need to provide and store pur-Periodicity and pur-StartTime in MAC layer.[1] (Ericsson)
* Handling of pur-ImplicitReleaseAfter is already captured in the currently endorsed specifications, eMTC TS 36.331 CR is aligned with the NB-IoT version.[1] (Ericsson)
* Similarly to RA and EDT, MAC determines the next available subframe containing PUR according to pur-Periodicity and pur-StartTime provided by RRC.[5] (Huawei, HiSilicon)
* RRC configures MAC with the previously stored pur-TimeAlignmentTimer (if any), if pur-Config is not present in the currently received RRC release message.[11] (ASUSTeK)
* RAN2 to discuss whether there is a need of adopting explicit exclusion to avoid PUR (in MAC and/or in RRC) been impacted when releasing all radio resources, or to confirm (through at least chairman’s note) that there is no impact of PUR on “release all radio resources” in section 5.3.12 of the RRC spec.[12] (ASUSTeK)
* In RRC\_IDLE, MAC entity decides whether to indicate HARQ feedback to the physical layer based on whether the pur-timeAlignmentTimer is running or not.[13] (ASUSTeK)

**Timing information / UL grant for PUR**

[1] and [5] discuss how the UL grant or timing information is provided to MAC layer from RRC layer and what should be captured in RRC and MAC specifications. [1] suggests to provide "UL grant" with timing information and [5] suggests to use similar mechanism as for RA/EDT, i.e. that MAC calculates the timing of the resources.

1. Capture calculation of PUR timing based on *pur-Periodicity* and *pur-StartTime* in TS 36.331 and remove Editor's note. FFS exact details.
2. Discuss whether MAC layer should also calculate exact PUR timing or whether RRC layer provides the information to MAC in the form of UL grant.

Q9: View on Proposal 14 – should MAC layer calculate the exact PUR timing or is it calculated in RRC layer and provided to MAC layer?

Proposal 13 can be further addressed once more details on *pur-StartTime* are agreed.

|  |  |  |
| --- | --- | --- |
| Company | MAC or RRC? | Comments (e.g. how and when information MAC needs is provided from RRC layer) |
| Huawei, HiSilicon | MAC | We think the PUR occasion is subframe level thus should be determined by MAC. Following similar approach in RA/EDT:*- 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);*The information needed in MAC can be provided when RRC configures MAC to use PUR. |
| LG | MAC | We agree with the Huawei comments.* We think the PUR occasion is subframe level thus should be determined by MAC.

The information needed in MAC can be provided when RRC configures MAC to use PUR. |
| Ericsson | Only RRC | If RRC layer calculates the exact timing, we think this should be provided to MAC after PUR has been triggered in "grant". How such grant is defined would be up to UE implementation but should contain the PUR timing so that it doesn't need to be explicitly recalculated in MAC, and would keep MAC as mush agnostic to PUR configuration as possible.  |
| Qualcomm | Only RRC | It seems we are going back and forth. Initially we said that MAC would keep track of the PUR exact TTIs, then that was reverted to say RRC keeps it, now the proposals say go back to MAC.This is the current RRC CR: (Also MAC has already been updated to just use the “grant” every time RRC indicates it).1> consider that the Nth PUR occasion occurs at H-SFN and subframe according to *pur-StartTime* and N \* *pur-Periodicity.*Editor’s Note: The details of the calculation of PUR occasion needs to be updated when we know more details on the start offset. The exact time (subframe/frame/hsf) needs to be provided here.After adding the details in RRC specification as indicated by Ed’s note above, we can rely on the UE implementation on when exactly RRC indicates this to MAC, but from spec point of view, the above means RRC knows exact TTI for the PUR occasion. |
| ASUSTeK | RRC | RRC provides to MAC in the form or UL grant. It is up to UE implementation exact timing of providing the preconfigured grant to MAC.  |
| Nokia | RRC | Earlier we preferred for MAC to handle the PUR information and also the operation. And we agreed to be maintained in RRC in last meeting. We prefer to continue with the same modelling. |
| ZTE2 | RRC | Generally agree with Ericsson. Moreover, different from RA, in which preamble retransmission can be triggered by MAC, PUR transmission on every PUR occasion is triggered by RRC. Since we already agree to let RRC maintain and calculate PUR timing, it’s no need to let MAC recalculate it. |
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| **Summary of Q9:**6 replies, where 2 companies prefer MAC and 4 companies RRC only. There is a majority for RRC thus for progress following is proposed: **Rapporteur proposal Q9: RRC layer calculates the exact PUR timing and provides the information to MAC in the form of UL grant. Details of the timing of providing this information to MAC layer is up to UE implementation.** |

**Other configuration information and remaining issues for PUR and MAC-RRC interaction**

The remaining proposals are suggested to be discussed further, either online, offline discussion or together with the corresponding CR discussions:

[1] proposes and [5] observers that *pur-implicitReleaseAfter* is captured already in the specifications and no further changes are needed. Therefore, no further proposal is provided on this.

[1] further discusses and proposes to explicitly provide PUR-RNTI when lower layers are configured for PUR and that *pur-ResponseWindowSize* is configured at the same time (i.e. not earlier when receiving *pur-Config*).

On TA timer for PUR, [11] proposes that RRC should configure MAC with previous TA timer in case there is no new *pur-Config* in the RRC release message in order to restart the PUR timer in case new configuration is not provided. [5] also discusses TA timer and observes the necessary interactions are already captured.

[12] brings up possible issue when RRC layer releases RRC connection, whether in such case *pur-Config* should be explicitly excluded, i.e. in "release all radio resources, including release of MAC configuration…" in RRC clause 5.3.12.

[13] proposes to add condition on checking whether *pur-TimeAlignmentTimer* is running when transmitting HARQ feedback in uplink.

1. Discuss the following remaining details of MAC-RRC interaction:

a) Should PUR-RNTI be explicitly provided when configuring lower layers to use PUR (after RRC triggers PUR transmission)?

Q10: Views on Proposal 15 a) – e)

|  |  |  |
| --- | --- | --- |
| Company | View on a) | Comments |
| Huawei, HiSilicon | Agree with the intention | But we think the current wording in RRC has covered PUR-RNTI, i.e. configures the lower layers to use PUR. With this sentence, MAC can get all configuration which is needed, similarly to RA/EDT. |
| LG | Yes |  |
| Ericsson | Yes | We think it would be clearer to have it explicitly visible in RRC specification when the PUR-RNTI is provided from RRC to MAC. Note that in current MAC PUR-RNTI is explicitly deleted after PUR transmission. In RA/EDT there is no RNTI allocation from RRC to MAC, but configuration of specific resources (e.g. PRACH etc.).  |
| Qualcomm | Yes | Except for PUR TA timer, everything else can be provided each time „configuring lower layers to use PUR“. So, in our mind, as also commented in the ASN.1 RIL, the main question is whether any further clarification is needed that PUR TA timer is not provided to MAC again for each PUR occasion. I.e., whther it is clear based on current RRC and MAC CRs that MAC needs to update TA timer only when RRC recieves PUR config in release message. |
| ASUSTeK | Yes |  |
| ZTE2 | Yes | Generally agree with the QC’s understanding that except for PUR TA timer, everything else can be provided each time “configuring lower layers to use PUR“. |

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| **Summary of Q10a:**5 replies, where all companies agree with the intention, one company says the current ording should cover this already and one company thinks it should be discussed existing specifications are clear on that TA timer is provded only once with *pur-Config.* .**Rapporteur proposal Q10a: Discuss further whether clarifications are needed for specification text when "configuring lower layers to use PUR" regarding PUR-RNTI and TA timer configuration.** |

b) Should *pur-ResponseWindowSize* be provided to MAC when *pur-Config* is received or when lower layers are configured to use PUR?

|  |  |  |
| --- | --- | --- |
| Company | View on b) | Comments |
| Huawei, HiSilicon | when lower layers are configured to use PUR | This parameter is only used during transmission using PUR. Thus it can be provided to MAC when lower layers are configured to use PUR  |
| LG | Yes |  |
| Ericsson | When lower layers are configured | Can be provided when lower layers are configured to avoid specifying storage in MAC during RRC\_IDLE outside of PUR transmissions.  |
| ASUSTeK | Yes |  |
| Nokia | When lower layers are configured |  |
| ZTE2 | When lower layers are configured to use PUR |  |

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| **Summary of Q10b:**5 replies, where 2 reply 'yes', but it is not clear which option this refers two. 3 companies indicate "when lower layers are configured" thus this is proposed:**Rapporteur proposal Q10b: *pur-ResponseWindowSize* is provided to MAC when lower layers are configured to use PUR.** |

c) How to address restarting *pur-TimeAlignmentTimer* in MAC if *pur-Config* is not present in RRC release?

|  |  |  |
| --- | --- | --- |
| Company | View on c) | Comments |
| Huawei, HiSilicon | NULL | The timer will keep running unless it is released explictly. The timer should not be restarted upon reception of RRC release message regardless pur-Config is present or not.5.8        MAC reconfigurationWhen a reconfiguration of the MAC entity is requested by upper layers, the MAC entity shall:-    upon addition of an SCell, initialize the corresponding HARQ entity;-    upon removal of an SCell, remove the corresponding HARQ entity;-    for timers apply the new value when the timer is (re)started;-    when counters are initialized apply the new maximum parameter value;-    for other parameters, apply immediately the configurations received from upper layers. |
| LG | NULL | PUR timer should not be restarted if pur-config is not included in RRCConnectionRelease. |
| Ericsson | TBD | We should clarify what is the intention when UE is released without *pur-Config*, e.g. wouldn't the UE have valid TA during connected? But on the other hand, as the timer also indicates the validity time for PUR configuration, it could be kept running if not explicitly restarted.  |
| ASUSTeK | Adopt the text proposal in [11]. | If PUR TA timer is not restarted upon entering IDLE, it may expire too early (although this may be a rare case). |
| ZTE2 | NULL | We disagree with the Observation in [11]. Anyway It’s possible that TA command MAC CE can be sent along with RRC release message, then *pur-TimeAlignmentTimer* would be restarted. So no need of additional process.We are not clear about HW’s comment why this is related to MAC reconfiguration? |

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| **Summary of Q10c:**4 replies where 2 companies say timer should not be restarted, one company says TBD and one company prefers the text proposal in [11]. There is small majority on not doing anything, thus for progress:**Rapporteur proposal Q10c: If *pur-Config* is not present in RRC release, *pur-TimeAlignmentTimer*** **is kept running.** |

d) Should PUR configuration be explicitly excluded in clause 5.3.12 in RRC when releasing the radio resource configuration?

|  |  |  |
| --- | --- | --- |
| Company | View on d) | Comments |
| Huawei, HiSilicon | No | We think PUR configuration is a different type of configuration. Thus it should not be covered by “all radio resouces“ in section 5.3.12.2> release all radio resources, including release of the MAC configuration, the RLC entity and the associated PDCP entity and SDAP (if any) for all established RBs; |
| Ericsson | Good to clarify | Good to clarify in TS 36.331 that radio resource release doesn't apply to PUR configuration.  |
| ASUSTeK | Yes | This could avoid any mis-interpretation in the future, and there is no harm to specify this in TS 36.331. |
| ZTE2 | Yes | We have no such understanding that *pur-config* is not covered by “all radio resouces“. So we are fine with the clarification. |

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| **Summary of Q10d:**3 replies, one company says no and two companies prefer to clarify, therefore:**Rapporteur proposal Q10d: Clarify that PUR configuration is excluded in clause 5.3.12 in TS 36.331 when releasing the radio resource configuration.** |

e) Should additional check if *pur-TimerAlignmentTimer* is running be added to MAC when transmitting HARQ feedback for PUR response message?

|  |  |  |
| --- | --- | --- |
| Company | View on e) | Comments |
| Huawei, HiSilicon | Yes | But we are not sure the wording in the TP is fully correct:- if both the *timeAlignmentTimer* and *pur-TimeAlignmentTimer*, associated with the TAG containing the serving cell on which the HARQ feedback is to be transmitted, are stopped or expired:- do not indicate the generated positive or negative acknowledgement to the physical layer.In RRC\_Connected, is that possible the legacy TA timer is stopped but the PUR TA timer is still running? If yes, the proposed wording seems not correct as the UE can still send HARQ feedback in this case. |
| Ericsson | Don't think this is needed |  |
| ASUSTeK | Yes | We agree with Huawei’s view that it is possible that the legacy TA timer is stopped but the PUR TA timer is still running in connected. Exact change to TS 36.321 could be discussed later if this issue is confirmed. |
| ZTE2 | Yes | Firstly, as we think it’s rare case that *pur-TimeAlignmentTimer* expires during PUR transmission, we don’t think the process to *pur-TimeAlignmentTimer* similar as that *timeAlignmentTimer* expires is needed. Moreover, we agree with HW’s comments that the proposed change is incorrect.Secondly, we agree there has another issue that the existing description about HARQ/ACK cannot be sent when *timeAlignmentTimer* is stopped or expired may have impacts on PUR transmission in RRC\_IDLE. E.g., such condition “*timeAlignmentTimer* is stopped or expired” can be considered also to be fulfilled in the PUR transmission case, therefore, it may cause that HARQ/ACK for PUR transmission cannot be generated.Our suggestion is just to exclude the PUR transmission from this process. The change example is as following:- except for transmission on preconfigured uplink grant for PUR: *- if the timeAlignmentTimer, associated with the TAG containing the serving cell on which the HARQ feedback is to be transmitted, is stopped or expired:**- do not indicate the generated positive or negative acknowledgement to the physical layer.**- else:**- indicate the generated positive or negative acknowledgement for this TB to the physical layer.* |

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| **Summary of Q10e:**3 replies, two companies support to add additional check and one company doesn't think there is a need. Thus: **Rapporteur proposal Q10e: Add additional check in MAC that *pur-TimeAlignmentTimer* is running when transmitting HARQ feedback for PUR response message.**The details can be discussed further e.g. in context of MAC CR.  |

## 2.4 RAN1 LSs

RAN2 has received two LSs from RAN1. One is a reply to earlier RAN2 questions on how repetition adjustments using DCI should be handled in [R2-2004342](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_110-e/Docs/R2-2004342.zip) and the other one is a new LS on RAN1 working assumption related to prioritization of CSS monitoring vs. PUR occasion in [R2-2004345](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_110-e/Docs/R2-2004345.zip). The following are related proposals:

* When repetition adjustment is provided in DCI, UEs PUR configuration is adjusted correspondingly by RRC layer. RAN2 specifies MAC-RRC interaction capturing this.[1] (Ericsson)
* Reply to RAN1 that from RAN2 perspective the working assumption on prioritizing PUR over monitoring CSS is OK.[1] (Ericsson)
* Send a reply LS to RAN1 confirming the feasibility of the working assumption on search space priority in PUR.[6] (Huawei, HiSilicon)
* Define (N)PUSCH repetition number for PUR as a one-shot parameter, i.e. it is only provided to PHY once.[6] (Huawei, HiSilicon)

For the working assumption on prioritization related to search space monitoring, it is proposed RAN2 confirms feasibility from RAN2 point of view:

1. Confirm the feasibility of RAN1 working assumption on search space priority, send a reply LS to RAN1.

On the repetition adjustment, two opposing views are provided in the submitted documents and considering also during earlier discussion there was no consensus, thus RAN2 should discuss which way to adopt and make corresponding specification changes if needed:

1. Choose between updating RRC configuration based on DCI repetition adjustment or storing the adjustment in PHY layer and using the latest value either from DCI or RRC.
2. Update specifications related to DCI repetitions adjustment, if needed, and communicate RAN2 outcome to RAN1.

Update after NB-IoT session on June 1st 2020:

Proposal 16 was agreed and wen have agreed to send an LS back to RAN1.

Remaining discussion is regarding Proposal 17, i.e. which way to adopt and how it would work from RAN2 point of view in detail.

**Q11: View on Proposal 17 (i.e. update RRC configuration or adjustment is stored in PHY layer)**

|  |  |  |
| --- | --- | --- |
| Company | View on P17 | Comments (e..g further details how it should work) |
| Huawei, HiSilicon | Update RRC configuration | We think updating RRC configuration is cleaner. In PHY, we think there is no concept of storing parameters, especially in IDLE mode.  |
| ZTE |  | We prefer to update RRC configuration based on DCI repetition adjustment and let only RRC maintain the latest value. |
| Ericsson | Update RRC | In our understanding the "adjustment" is absolute value so in the end we think it would be cleaner to update RRC configuration with the value and use that for following PUR occasions and use this value when configuring lower layers.  |
| Qualcomm | Strongly prefer to Keep in PHY | For eMTC, currenlty the interpretation of the DCI signalled value is captured in two Tables in RAN1 spec 36.213:Table 8-2b: PUSCH repetition levels (DCI Format 6-0A)

|  |  |
| --- | --- |
| Higher layer parameter'*pusch-maxNumRepetitionCEmodeA*' |  |
| Not configured | {1,2,4,8} |
| 16 | {1,4,8,16} |
| 32 | {1,4,16,32 } |

Table 8-2c: PUSCH repetition levels (DCI Format 6-0B)

|  |  |
| --- | --- |
| Higher layer parameter'*pusch-maxNumRepetitionCEmodeB*' |  |
| Not configured | {4,8,16,32,64,128,256,512} |
| 192  | {1,4,8,16,32,64,128,192} |
| 256  | {4,8,16,32,64,128,192,256}  |
| 384  | {4,16,32,64,128,192,256,384}  |
| 512  | {4,16,64,128,192,256,384,512}  |
| 768  | {8,32,128,192,256,384,512,768} |
| 1024  | {4,8,16,64,128,256,512,1024}  |
| 1536  | {4,16,64,256,512,768,1024,1536} |
| 2048  | {4,16,64,128,256,512,1024,2048} |

In the above tables, the left column is signalled in SIB. The right column provides mapping to the actual value used based on the adjustment codepoint singalled in the DCI. First of all, in RRC, currently the value for repetition is bit string of size 3 because according to 36.213 and RAN1 LS, it can be 2 or 3 bits depending on the scenario. For DCI indicated adjustment, it is either 2 or 3 bits as shown above (depending on CE Mode). How does the RRC figure out what/how to store/update RRC parameter based on the DCI value? Who tells this to RRC? Do we copy the above mapping to RRC specification? Or just refer to RAN1 tables? And suppose RRC stores „value“, does that mean store the index or the value?Question to proponens of „update RRC“: **What is your proposal on how to capture this in RRC? Please provide the TP for RRC.**Updating RRC parameter based on DCI signalled value is not done before in the spec, so it is better to keep that distinction.RAN1 has already endorsed TP to take care of the either case depending/conditional on what RAN2 agrees. Therefore RAN2 needs to take easier approach.**Given that there is a lot of RRC specification work without clear technical reason, we strongly believe this should be kept in PHY.**FYI, for NB-IoT shown below, it is much easier to update RRC because there is one absolute value, a single table, always 3 bits for index, no need to refer to a parameter in SIB etc. But that is not the case for eTMC.Table 16.5.1.1-3: Number of repetitions () for NPUSCH.

|  |  |
| --- | --- |
|  |  |
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |
|  |  |

 |
| Nokia | RRC | The absolute value of repetitions which was used for last uplink transmission which was successful can be provided to RRC. Maintaining all the information of uplink grant including the number of repetitions in one place (RRC) is preferred. As indicated by Huawei, not sure whether physical layer is maintaining UE context to store the repetitions in idle state |

|  |
| --- |
| **Summary of Q11:**5 replies where 4 companies prefer to update RRC configuration, one company strongly prefers to keep it in PHY layer with further technical concerns. As there are concerns, and easy agreement based on majority seems not possible:**Rapporteur proposal Q11: Discuss further whether to update RRC or keep DCI adjustment on repetitions in PHY layer taking into account the technical concerns which have been brought up.** |

Update after session on June 3rd:

The working assumption is to update RRC based on the DCI. In the following new question companies are asked to provide details on how it should work:

**Q12: Please provide details on how to capture "Working assumption: Update RRC with DCI adjustment on repetitions" in RAN2 specifications for both eMTC and NB-IoT:**

|  |  |
| --- | --- |
| Company | Comments (text proposals are encouraged) |
| Ericsson | The adjustment update can be captured in RAN2 specifications as follows: MAC layer already monitors for PUR SS window after PUR occasion for responses. If UE receives an ACK for PUR including a repetition adjustment, MAC layer passes this information to RRC layer. We already have MAC/RRC interaction for indicating success/fallback based on such ACK. Same mechanism can be used to convey the adjustment information to RRC.When RRC receives the adjustment from MAC, it updates the *pur-Config* and the corresponding repetition configuration accordingly.For LTE-M, *numRepetitions* can be updated depending on if CE Mode A or B is used, The mapping of *numRepetitions* is specified in TS 36.312 clause 8.0 for these cases, also for CE Mode A case when *ce-pdsch-puschEnhancement-config* is enabled. In our understanding the value of the adjustment in the DCI is exactly the same as the index for the tables/definitions in TS 36.213 which is also exactly what is stored in *numRepetitions.* Thus there is no particular need for RRC layer to interpret the meaning of the value of the adjustment, but the configuration can be updated based on what was provided by the lower layers. The field description for *numRepetitions* already mentions the reference to TS 36.213 and where the interpretation of the stored value can be found, if needed. In similar way for NB-IoT, *npusch-NumRepetitionsIndex* in *Pur-Config-NB* can be updated.When RRC layer triggers PUR the next time, lower layers are configured for PUR transmission as already captured (i.e. including the PUR grant), and PHY would get the correct number of repetitions to be used based on this configuration.For example, in TS 36.321 following can be added in 5.4.7.1:While *pur-ResponseWindowTimer* is running, the MAC entity shall:- if the PDCCH transmission is addressed to the PUR-RNTI and contains an UL grant for a retransmission:- restart *pur-ResponseWindowTimer* at the last subframe of a PUSCH transmission corresponding to the retransmission indicated by the UL grant plus 4 subframes;- if PDCCH indicates L1 ACK for transmission using PUR; or- if PDCCH transmission is addressed to the PUR -RNTI and the MAC PDU is successfully decoded:- stop *pur-ResponseWindowTimer*;- if PDCCH indicates L1 ACK for transmission using PUR or the MAC PDU contains only Timing Advance Command MAC control element :- indicate to upper layers the transmission using PUR was successful;- if PDCCH includes repetition adjustment for the next PUR occasion: - indicate the value of the repetition adjustment to upper layers. - discard the PUR-RNTI.- else if PDCCH indicates fallback for PUR:- stop *pur-ResponseWindowTimer*;- indicate to upper layers PUR fallback indication is received. - discard the PUR-RNTI.- if the *pur-ResponseWindowTimer* expires:- indicate to upper layers the transmission using PUR has failed; - discard the PUR-RNTI.And in TS 36.331 the update can be captured e.g. in "Maintenance of PUR occasions" section:5.3.3.x Maintenance of PUR occasionsThe UE configured with *pur-Config* shall:1> consider that the Nth PUR occasion occurs at H-SFN and subframe according to *pur-StartTime* and N \* *pur-Periodicity.*Editor’s Note: The details of the calculation of PUR occasion needs to be updated when we know more details on the start offset. The exact time (subframe/frame/hsf) needs to be provided here.1> if the *pur-NumOccasions* is set to *one*, after the occurence of the first PUR occasion:2> release *pur-Config*;2> discard previously stored *pur-Config*;1> else ~~if the~~ *~~pur-ImplicitReleaseAfter~~* ~~is configured,~~ for each PUR occasion occurring while the UE is in RRC\_IDLE:  2> if PUR repetition adjustment is received from lower layers: 3> update number of repetitions in *pur-Config* according to the adjustment; 2> if the *pur-ImplicitReleaseAfter* is configured: ~~2~~3> if transmission using PUR in accordance with conditions in 5.3.3.1c is not initiated; or ~~2~~3> if PUR failure indication is received from lower layers: ~~3~~4> consider the PUR occasion as skipped; ~~3~~4> if *pur-ImplicitReleaseAfter* number of consecutive PUR occasions have been skipped: ~~4~~5> release *pur-Config*; ~~4~~5> discard previously stored *pur-Config*;The details of the above TPs can be further revised based on these examples e.g. if we want to clarify the processing of the exact parameter to be updated for eMTC or NB-IoT. |
| ZTE2 | We understand the current physical layer indication can indicate the following four info: L1 ACK, fallback for PUR, TA and also PUSCH repetition adjustment. The first three info have been handled in MAC. So we can follow the similar way to handle PUSCH repetition adjustment info. In short, we are generally fine with Ericsson’s suggestion. And based on this, maybe we don’t need to ask RAN1 to introduce some notification to higher layer in their spec.  |
|  |  |
|  |  |
|  |  |

# 3 Summary [to be updated]

The following is the summary and rapporteur proposals based on the first offline discussion for PUR:

**Summary for Q1:**

8 replies with 5 answers for 2) and 2 for 1). One company preferring 1) is OK with 2). Based on majority, proposal is to go with 2). In details there are still some concerns on overhead, but some support for 6 or 7 bits configurations so 6/7 bits are proposed, with need to truncate the "full list" by couple of values:

**Rapporteur proposal Q1: For *requestedTBS,* use 64 values for eMTC and 32 values for NB-IoT. Further decide which exact values are included.**

**Summary for Q2:**

8 replies where 6 replies support P3 and P4 and assume relative offset, given that the offset value range is larger than 1024 H-SFN. 1 company supports offset range of up to 1024 H-SFN and assuming that, absolute value, otherwise relative offset. 1 company is fine either way.

Proposals are suggested below after question related to original P7 and P8.

**Summary for Q3:**

8 replies where all companies support adopting a multi-level structure. The exact details can be worked out when all agreements on range and values are in place – see proposal Q5.

**Summary for Q4:**

8 replies where 4 companies indicate clear 'yes' and 2 companies a clear 'no'. One company replies 'yes/no' but based on comments they seem to think the offset should be larger than maximum periodicity. One company is fine either way. Based on the replies there seems to be more support for longer offset than 1024 H-SFN, however it seems clarifications would be best discussed further online, therefore:

**Rapporteur proposal Q4: Discuss further whether the working assumption on requested offset should be confirmed or not.**

The proposal related to above Q2 and original P3, P4, P5 depend on the outcome of the discussion.

*Proposals conditional on confirming the working assumption:*

The next two proposals are the original P3 and P4 which were supported by majority in Q2:

**Rapporteur proposal Q4a: Confirm that PUR starting time configuration in *pur-StartTime* is an offset relative to a reference H-SFN.**

**Rapporteur proposal Q4b: *pur-StartTime* reference is the H-SFN corresponding to the last subframe of the first transmission of RRC release message containing *pur-Config*.**

The alignment issue was not discussed in detail in many of the replies thus needs to be discussed and decided further:

**Rapporteur proposal Q4c: Discuss further whether the working assumption on requested offset should be confirmed or not.**

*Proposals conditional on reverting the working assumption:*

If the working assumption on maximum offset is reverted and e.g. the H-SFN is indicated in existing signalling, then it is proposed to adopt absolute indication of H-SFN instead

**Rapporteur proposal Q4d: H-SFN level is indicated in absolute terms, i.e. the configuration indicates the starting H-SFN according to signaled H-SFN value.**

**Summary of Q5:**

7 replies where majority of companies seem to prefer baseline of separate H-SFN, SFN and SF ranges. No strong opinions on possible optimizations are brough up, therefore full ranges are proposed as baseline:

**Rapporteur proposal Q5: Following structure is adopted as baseline for *pur-StartTime*:**

pur-StartTime-r16 ::= SEQUENCE {

 pur-startHSFN-r16 INTEGER (0..1023) OR INTEGER (0..8191),

 pur-startSFN-r16 INTEGER (0..1023),

 pur-startSubframe-r16 INTEGER (0..9)

}

Possible optimizations of above and whether there is need e.g. for additional H-SFN cycle level can be discussed further.

**Summary of Q6:**

6 replies, where 4 companies reply yes, one company conditional yes depending on the exact values for H-SFN level configuration and one company doens't have a direct reply but comments it needs to be in H-SFN level (which is already agreed). Proposal at this stage is revisit this discussion once H-SFN level configuration in *pur-StartTime* has been discussed and decided.

**Rapporteur proposal Q6: Revisit discussion on requested offset range once H-SFN level in *pur-StartTime* has been decided.**

**Summary of Q7:**

8 replies, where all companies reply yes. Issues have been brought up but it is assumed RAN2 is able to solve such issues in one way or another

**Rapporteur proposal Q7: It is up to eNB implementation how UE and PUR configuration are linked according to the configured PUR resources.**

**Summary of Q8:**

7 replies, where all companies support the intention for resolve the issues brought up. Two companies explicitly support the way proposed in [1] and two companies prefer the way proposed in [9]. Of the three remaining companies, two have additional suggestions e.g. to store PUR configuration in MME which would be fetched using S-TMSI, or sending back the PUR-RNTI when establishing connection. One remaining company supports identifier with additional information.

**Rapporteur proposal Q8a: For CP-PUR, RAN2 intends to address the case of reconfiguration/release and 'm' counting so that PUR works properly.**

**Rapporteur proposal Q8b: Discuss further which mechanism is adopted to address the issues mentioned in Proposal Q8a.**

**Summary of Q9:**

6 replies, where 2 companies prefer MAC and 4 companies RRC only. There is a majority for RRC thus for progress following is proposed:

**Rapporteur proposal Q9: RRC layer calculates the exact PUR timing and provides the information to MAC in the form of UL grant. Details of the timing of providing this information to MAC layer is up to UE implementation.**

**Summary of Q10a:**

5 replies, where all companies agree with the intention, one company says the current ording should cover this already and one company thinks it should be discussed existing specifications are clear on that TA timer is provded only once with *pur-Config.* .

**Rapporteur proposal Q10a: Discuss further whether clarifications are needed for specification text when "configuring lower layers to use PUR" regarding PUR-RNTI and TA timer configuration.**

**Summary of Q10b:**

5 replies, where 2 reply 'yes', but it is not clear which option this refers two. 3 companies indicate "when lower layers are configured" thus this is proposed:

**Rapporteur proposal Q10b: *pur-ResponseWindowSize* is provided to MAC when lower layers are configured to use PUR.**

**Summary of Q10c:**

4 replies where 2 companies say timer should not be restarted, one company says TBD and one company prefers the text proposal in [11]. There is small majority on not doing anything, thus for progress:

**Rapporteur proposal Q10c: If *pur-Config* is not present in RRC release, *pur-TimeAlignmentTimer*** **is kept running.**

**Summary of Q10d:**

3 replies, one company says no and two companies prefer to clarify, therefore:

**Rapporteur proposal Q10d: Clarify that PUR configuration is excluded in clause 5.3.12 in TS 36.331 when releasing the radio resource configuration.**

**Summary of Q10e:**

3 replies, two companies support to add additional check and one company doesn't think there is a need. Thus:

**Rapporteur proposal Q10e: Add additional check in MAC that *pur-TimeAlignmentTimer* is running when transmitting HARQ feedback for PUR response message.**

The details can be discussed further e.g. in context of MAC CR.

**Summary of Q11:**

5 replies where 4 companies prefer to update RRC configuration, one company strongly prefers to keep it in PHY layer with further technical concerns. As there are concerns, and easy agreement based on majority seems not possible:

**Rapporteur proposal Q11: Discuss further whether to update RRC or keep DCI adjustment on repetitions in PHY layer taking into account the technical concerns which have been brought up.**

***List of proposals:***

**TBS**

**Rapporteur proposal Q1: For *requestedTBS,* use 64 values for eMTC and 32 values for NB-IoT. Further decide which exact values are included.**

**PUR offset working assumption and the H-SFN configuration**

**Rapporteur proposal Q4: Discuss further whether the working assumption on requested offset should be confirmed or not.**

**CONDITIONAL ON Q4:**

**Rapporteur proposal Q4a: Confirm that PUR starting time configuration in *pur-StartTime* is an offset relative to a reference H-SFN.**

**Rapporteur proposal Q4b: *pur-StartTime* reference is the H-SFN corresponding to the last subframe of the first transmission of RRC release message containing *pur-Config*.**

**Rapporteur proposal Q4c: Discuss further whether the working assumption on requested offset should be confirmed or not.**

**Rapporteur proposal Q4d: H-SFN level is indicated in absolute terms, i.e. the configuration indicates the starting H-SFN according to signaled H-SFN value.**

***pur-StartTime* structure and requested offset**

**Rapporteur proposal Q5: Following structure is adopted as baseline for *pur-StartTime*:**

pur-StartTime-r16 ::= SEQUENCE {

 pur-startHSFN-r16 INTEGER (0..1023) OR INTEGER (0..8191),

 pur-startSFN-r16 INTEGER (0..1023),

 pur-startSubframe-r16 INTEGER (0..9)

}

**Rapporteur proposal Q6: Revisit discussion on requested offset range once H-SFN level in *pur-StartTime* has been decided.**

**CP configuration**

**Rapporteur proposal Q7: It is up to eNB implementation how UE and PUR configuration are linked according to the configured PUR resources.**

**Rapporteur proposal Q8a: For CP-PUR, RAN2 intends to address the case of reconfiguration/release and 'm' counting so that PUR works properly.**

**Rapporteur proposal Q8b: Discuss further which mechanism is adopted to address the issues mentioned in Proposal Q8a.**

**Corrections / clarifications on MAC/RRC:**

**Rapporteur proposal Q9: RRC layer calculates the exact PUR timing and provides the information to MAC in the form of UL grant. Details of the timing of providing this information to MAC layer is up to UE implementation.**

**Rapporteur proposal Q10a: Discuss further whether clarifications are needed for specification text when "configuring lower layers to use PUR" regarding PUR-RNTI and TA timer configuration.**

**Rapporteur proposal Q10b: *pur-ResponseWindowSize* is provided to MAC when lower layers are configured to use PUR.**

**Rapporteur proposal Q10c: If *pur-Config* is not present in RRC release, *pur-TimeAlignmentTimer*** **is kept running.**

**Rapporteur proposal Q10d: Clarify that PUR configuration is excluded in clause 5.3.12 in TS 36.331 when releasing the radio resource configuration.**

**Rapporteur proposal Q10e: Add additional check in MAC that *pur-TimeAlignmentTimer* is running when transmitting HARQ feedback for PUR response message.**

**RAN1 LSs:**

**Rapporteur proposal Q11: Discuss further whether to update RRC or keep DCI adjustment on repetitions in PHY layer taking into account the technical concerns which have been brought up.**

# 4 References

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