**3GPP TSG-RAN WG2 Meeting #116 electronic  *R2-210xxxx***

**1th November – 12th November 2021**

**Agenda item: 9.1.3**

**Source: ZTE (email discussion rapporteur)**

**Title: Report of [Post116-e][311][NBIOT/eMTC R17] NB-IoT carrier selection**

**Document for: Discussion and Decision**

# Introduction

This document is the report of the offline email discussion “*[Post116-e][311][NBIOT/eMTC R17] NB-IoT carrier selection*”, as indicated below:

* *[Post116-e][311][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)*

*Scope: open issues and solution details*

*Intended outcome: report to the next meeting*

*Deadline: long (December 17th, 0900 UTC)*

# Contact information

Please provide your contact information when feedback:

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# Discussion

In RAN2#116 e-meeting, RAN2 has achieved the following agreements:

|  |
| --- |
| *Agreements:*   * *DRX is not used a criterion that needs to be explicitly considered for paging carrier selection.* * *Option 1c with Alt2 (fallback when cell change) is supported.* |

Based on the previous meeting discussion, the description of Option 1c with Alt2 is as following:

* Option 1c: Network enables UE to select a Rel-17 paging carrier by providing the “coverage level” information (Rmax/CEL) for the carrier selection to the UE in dedicated signaling.
  + - Alt2: fallback to legacy carrier selection scheme when cell change.

In this email discussion, the details of Option 1c are discussed.

The following procedure flow for Option 1c is copied from [R2-2110191] for reference:



## Information assigned via dedicated signalling

According to the discussion in the previous meetings, for Option 1c, the eNB would provide a coverage level related information to the UE during RRC connection release procedure. As mentioned in [R2-2110110], such information can be a certain Rmax/NPDCCH repetitions for decoding NPDCCH. Moreover, such information already can be estimated by the eNB based on UE’s service quality in connected mode and sent to MME/AMF (in *UEPagingCoverageInformation-NB*-> *npdcch-NumRepetitionPaging*) for subsequent PAGING.

### Rmax in dedicated signalling

**Q1-01: Do companies agree that eNB would provide a Rmax information, e.g., *npdcch-NumRepetitionPaging,* to the UE when UE is released to idle?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We think it can also be allowed to provide Rmax information in Msg4 in EDT or PUR procedure.  Moreover, we have assumption that the Rmax/*npdcch-NumRepetitionPaging* in RRC connection release message have same value range as that for Rmax/*npdcch-NumRepetitionPaging* in R17 paging carrier list in SIB. |
| Ericsson | Yes but | We prefer Rmax over CEL and propose to introduce means to adjust due to changes in transmission power, i.e., when network decides to boost power for some paging carriers and thus reduce the number of repetitions required to decode NPDCCH that schedules the paging message. This can be done by mapping the Rmax to an index value during release and providing the information on association via broadcasting signaling in the serving cell |
| Huawei/ HiSilicon | probably no | We think this should be discussed together with the NRSRP threshold(s) in 3.3.1.  We are not quite sure about the purpose of the Rmax. Does the UE perform carrier selection based on Rmax or based on NRSRP ? What if there is no paging carrier configured with the assigned Rmax ? We do not think that Rmax information on its own is enough. We think the coverage information provided to the UE should be related to NRSRP, e.g. ‘coverage level’. |
| Qualcomm | Maybe | Considering the information in the SIB for each coverage-based paging carrier needs to have the Rmax and the corresponding minimum RxLevel/NRSRP then either NRSRP or Rmax can work as long as now two paging carriers have same NRSRP but different Rmax or different NRSRP and same Rmax. Alternatively, network can indicate the coverage-based paging carrier index and UE will use the NRSRP configured for this coverage-based paging carrier index to decide whether to use coverage-based paging carrier or legacy paging carrier. |
| MediaTek | Yes | NRSRP as the information provided to UE is also acceptable. |

**Conclusion:**

### Enable/disable indication in dedicated signalling

In [R2-2110149], company suggests that for UE in extended coverage, it can be disabled CEL-based paging carrier selection via RRC release message.

**Q1-02: Do companies agree that UE can be enabled/disabled CEL-based paging carrier selection when UE is released to idle?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | The provision of Rmax information, e.g., *npdcch-NumRepetitionPaging* in RRC connection release message can act as an implicit enable indication. Without Rmax information in RRC connection release message, the UE is disabled CEL-based paging carrier selection. That means it should still use legacy paging carrier selection scheme. |
| Ericsson | Yes | We think there is no need for an explicit indication; agree with ZTE that presence or absence of e.g., Rmax would simply be enough |
| Huawei, HiSilicon | Yes | We think we have already agreed that the use of the scheme for a given UE will be enabled via dedicated signaling. |
| Qualcomm | Yes | Not only the network must have a ability to instruct the UE to not use coverage-based paging carrier but it is also useful for UE to be able to indicate it does not wish to use coverage-based paging carrier without the need to UE to change its capability. |
| MediaTek | Yes |  |

**Conclusion:**

## R17 carrier list configuration in SIB

According to the discussion in previous meetings, for Option 1c, the possible contents in the R17 carrier list configuration in SIB has been mentioned as following:

* Each R17 paging carrier can be configured with a *npdcch-NumRepetitionPaging*. One or more R17 paging carriers can be configured with the same *npdcch-NumRepetitionPaging* that means these paging carriers are corresponding to a same coverage level. Different coverage levels can be supported with different *npdcch-NumRepetitionPaging*.
* A common *nB* value (which may be different from (e.g., larger than) the cell *nB*) can be configured to all R17 paging carriers with the same *npdcch-NumRepetitionPaging.* (That means this parameter is coverage specific).
* A common coverage specific DRX cycle can be configured to all R17 paging carriers with the same *npdcch-NumRepetitionPaging*. Or the simplest, it's no need to configure coverage specific DRX cycle and then the cell-specific default paging cycle can still be applied.
* A common coverage specific *ue-SpecificDRX-CycleMin* (which may be different from (e.g., smaller than) the cell specific *ue-SpecificDRX-CycleMin*) can be configured to all R17 paging carriers with the same *npdcch-NumRepetitionPaging*.

### Rmax for R17 paging carrier in SIB

**Q2-01: Do companies agree that one or more R17 paging carriers can be configured with a same Rmax parameter, e.g., *npdcch-NumRepetitionPaging,* that means these paging carriers are corresponding to a same coverage level?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We assume this is just for Stage-2 agreement. For stage-3, it can be further discussed. One possible way is to always configure *npdcch-NumRepetitionPaging* for each R17 coverage-based paging carrier and mention one or more R17 paging carriers can be configured with a same *npdcch-NumRepetitionPaging* value. Or another way is to configure a R17 paging carrier list for each configured *npdcch-NumRepetitionPaging* value. |
| Ericsson | Yes | An operator should be able to configure multiple paging carriers with the same Rmax value. |
| Huawei, HiSilicon | Yes. | That is why we think that providing Rmax information to the UE is not useful. |
| Qualcomm | Yes | In theory more than one coverage based paging carrier can be configured for the same coverage level and UE\_ID can be used to select one coverage based paging carrier from the set. In practice, it is highly unlikely more than one coverage based paging carrier will be configured for the same coverage level. For this reason and to minimize signalling overhead, it makes sense to limit the number of paging carriers configured for a specific coverage level e.g., up to 2, and/or to the maximum carriers in the coverage-based list e.g., 4. |
| MediaTek | Yes | The possibility of deploying more paging carriers by operator should not be limited. |

**Conclusion:**

### Different CELs for R17 paging carrier

During the email discussion, some companies think different coverage levels can be allowed. However, as some companies think that it’s likely to be very few coverage-based paging carriers in a cell, they think the realistic assumption seems to be that there are only a few different coverage levels and generally only very few paging carriers, e.g., 1, for each given coverage level.

In [R2-2110149], company also suggest that for simple UE and network implementations, division of paging carriers into two subsets of carriers each mapped to normal and maximum coverage is considered as basis for paging carrier selection. And, optionally the Rel-17 paging carriers can be further divided into two sub-groups based on CEL.

**Q2-02: Do companies agree that different coverage levels (e.g., more than one coverage levels) in R17 paging carrier list would be allowed? If answer is “Yes”, please indicate preferred number.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | With trade-off between flexibility and complexity, we think 3 or 4 Rmax values can be allowed to configure in Rel-17 paging carrier list in SIB to achieve 3 or 4 coverage levels, e.g., 3 or 4 sub-groups of Rel-17 paging carrier. |
| Ericsson | Yes | We think the set of possible Rmax values, as in legacy covering coverage from good to deep, should be supported with no restriction on the maximum number of different Rmax values that can be assigned to a particular paging carrier. |
| Huawei, HiSilicon | Probably No | We think a single set of R17 carriers corresponding to ‘normal coverage’ as defined in RAN4 is enough. We think having defining multiple levels is providing a flexibility that will never be used due to the associated signaling overhead. we although need to consider the ‘low’ accuracy of NRSRP measurements. |
| Qualcomm | Maybe | Greater granularity of coverage based paging carriers leads to more radio resources reserved for paging. In principle we don’t think any more granularity than currently supported for PRACH resources is warranted. Given that legacy paging carriers cover the entire cell, we propose at most two coverage levels are supported for by coverage-based paging carrier and both of these coverage levels should be smaller than the coverage level supported by legacy paging carrier. |
| MediatTek | Yes | Since the worst coverage level can be provided by the legacy paging carrier, there is no point to support deep coverage in Rel-17 paging carriers. Comparing to 3 coverage levels of NPRACH resource, 2 coverage levels for Rel-17 paging carrier seems reasonable. |

**Conclusion:**

### Value range for Rmax in SIB

In [R2-2110149], company suggest for UE in deep coverage, it can be disabled CEL-based paging carrier selection via RRC release message. That means it should still use legacy paging carrier selection scheme. For UE in good or normal coverage, it can be enabled CEL-based paging carrier selection via RRC release message.

Per rapporteur’s understanding, company may have assumption that network can only configure R17 paging carriers for good or normal coverage. That may further means the value range for Rmax, e.g., *npdcch-NumRepetitionPaging* can be less than r2048.

**Q2-03: Companies are invited to give your preference for the value range of the configured *npdcch-NumRepetitionPaging* for R17 paging carrier (list):**

* **Alt1: Same as legacy, e.g., *npdcch-NumRepetitionPaging-r17 ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128, r256, r512, r1024, r2048, spare4, spare3, spare2, spare1}***
* **Alt2: With limited values, e.g., *npdcch-NumRepetitionPaging-r17 ENUMERATED {r1, r8, r32, r64},* the possible values can be discussed later**
* **Alt3: Other**

|  |  |  |
| --- | --- | --- |
| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 | We are fine with either Alt1 or Alt2 but prefer Alt1.  For Alt1, a large value range can be provided. This is beneficial to configuration flexibility. Maybe some restriction (e.g., at most 3 or 4 coverage levels are supported) can be mentioned.  For Alt2, there is implicit assumption that for UE in deep coverage (e.g., the required repetition number is larger than r64), they cannot use R17 paging carrier. This is acceptable but a bit restricted. |
| Ericsson | Alt1 |  |
| Huawei. HiSilicon | FFS | We think we could probably remove the top 8 values as the enhancement is aimed to UEs in ‘good’ coverage and this save 1 bit. However, if there can be no quick agreement, it is not worth spending hours discussing a new range. |
| Qualcomm | Alt2 | In-line with our response for Q2-02, the Rmax value only needs to support up to coverage level 1 (assuming coverage level 0 is the best and coverage level 2 is the worst). Therefore, in theory r2048 corresponds to the worst coverage level and this should not be used for coverage-based paging carriers. |
| MediaTek | Alt2 |  |

**Conclusion:**

### *nB* for R17 paging carrier

In [R2-2110475], company gives explanation that in NB-IoT, the low values of the paging occasion density (nB) were motivated by the potentially large number of NPDCCH repetitions and the desire to avoid PO overlapping between different UEs. Thus, with R17 carriers being configured with lower number of NPDDCH repetition, it could make sense to allow for larger paging occasion density (nB) on the R17 paging carriers. This is also common understanding from some other companies. According to the previous discussion, different alternatives have been mentioned, e.g., nB configuration on carrier basis or commonly for carriers with the same number of NPDCCH repetitions.

**Q2-04: Companies are invited to give your preference for nB configuration for R17 paging carrier (list):**

* **Alt1: coverage specific nB, which means a common nB value is configured to the R17 paging carriers with same *npdcch-NumRepetitionPaging***
* **Alt2: carrier specific nB, which can be configured differently for each R17 paging carrier.**
* **Alt3: no nB configuration. That means cell specific nB would be applied.**

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| --- | --- | --- |
| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 |  |
| Ericsson | Alt1 |  |
| Huawei, HiSilicon | Alt1 |  |
| Qualcomm | Alt1 | A lower Rmax allows for more paging occasions to be supported hence it makes sense to make use of this. Given that RAN2 has already agreed not to use carrier specific DRX for coverage-based paging carrier selection then it is reasonable to have same nB and DRX for the coverage-based paging carriers for the same coverage level. |
| MediaTek | Alt1 |  |

**Conclusion:**

### DRX cycle for R17 paging carrier

In previous discussion, some companies have suggested to allow carrier specific DRX cycle configuration as the number of NPDCCH /NPDSCH repetitions will be lower and this could provide more paging flexibility to the NW.

However, as mentioned in [R2-2110475], there are also arguments that this would mean that some UEs (depending on the value of their UE specific DRX if configured) would monitor paging and perform measurements more often and thus impact the power consumption.

**Q2-05: Companies are invited to give your preference for DRX cycle configuration for R17 paging carrier (list):**

* **Alt1: coverage specific DRX cycle, which means a common DRX cycle value is configured to the R17 paging carriers with same *npdcch-NumRepetitionPaging***
* **Alt2: carrier specific DRX cycle, which can be configured differently for each R17 paging carrier.**
* **Alt3: no DRX cycle configuration. That means cell specific default DRX cycle would be applied.**

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| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 | RAN2 has agreed that “*DRX is not used a criterion that needs to be explicitly considered for paging carrier selection*”. Therefore, we think it’s no need to configured carrier specific DRX cycle.  For configuration flexibility, we still a bit prefer to support coverage specific DRX cycle. Although NW would configure this value to correspond to the related coverage level, as NW cannot predict the traffic frequency of the UEs that selects this coverage level, we assume generally NW would not configure this value too much smaller than the cell specific default DRX cycle.  For Alt1, we assume no additional UE behavior needs to be specified as UE can uniquely determine this DRX cycle as long as a paging carrier is selected based on the assigned Rmax.  This coverage specificDRX cycle can be used as default DRX cycle instead of the previous cell specific default paging DRX cycle. |
| Ericsson | Alt1 |  |
| Huawei, HiSilicon | Alt3 | Configuring a shorter DRX cycle for UE in good coverage will lead to UE having to monitor paging and perform measurements more often. This would also not bring any benefit in paging delay, as the CN is only aware of the cell default DRX cycle and UE specific DRX. |
| Qualcomm | Alt1 | As per our response to Q2-05, all paging carriers with the same coverage level should have the same DRX. |
| MediaTek | Alt3 | Impact on power consumption. For those UEs which actually need shorter DRX cycle, UE specific DRX cycle is enough. |

**Conclusion:**

### *ue-SpecificDRX-CycleMin* for R17 paging carrier

As mentioned in [R2-2110475], the reason for the introduction of cell specific parameter *ue-SpecificDRX-CycleMin* is to avoid CSS overlapping for a given UE if the large numbers of NPDCCH repetitions is needed. Therefore, it seems reasonable to allow smaller *ue-SpecificDRX-CycleMin* on the R17 paging carriers. In addition, as the *ue-SpecificDRX-CycleMin* is directly linked to the number of NPDCCH repetitions, there is no reason to have different values for R17 paging carriers with the same number of NPDCCH repetitions.

**Q2-06: Companies are invited to give your preference for *ue-SpecificDRX-CycleMin* configuration for R17 paging carrier (list):**

* **Alt1: coverage specific *ue-SpecificDRX-CycleMin*, which means a common *ue-SpecificDRX-CycleMin* value is configured to the R17 paging carriers with same *npdcch-NumRepetitionPaging.***
* **Alt2: carrier specific D *ue-SpecificDRX-CycleMin*, which can be configured differently for each R17 paging carrier.**
* **Alt3: no *ue-SpecificDRX-CycleMin* configuration. That means cell specific *ue-SpecificDRX-CycleMin* would be applied.**

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| --- | --- | --- |
| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 | As the *npdcch-NumRepetitionPaging* could be configured with relatively small value for the carriers corresponding to a certain coverage level, in order to avoid CSS overlapping, we need to introduce the corresponding coverage specific *ue-SpecificDRX-CycleMin.* This is out of the reason similar to that for introducing cell specific *ue-SpecificDRX-CycleMin*. |
| Ericsson | Alt1 |  |
| Huawei, HiSilicon | Alt1 |  |
| Qualcomm | Alt1 | Think this question is redundant. |
| MediaTek | Alt1 |  |

**Conclusion:**

### *PagingWeight*

In [R2-2110191], company think if UE selected more than one carrier based on coverage, paging weight can be used for network to perform load balancing when determining one from these selected carriers.

In [R2-2110695], company think that it is highly unlikely there would be more than one paging carrier for a specific coverage level lower than maximum coverage level in the cell. For that reason, if a coverage-based paging carrier is more appropriate for a UE then it should always select that carrier. Therefore, company suggest that paging Weight is not used for selecting coverage-based paging carrier.

**Q2-07: Do companies agree that paging weight can still be used in coverage-based paging carrier selection?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We firstly think assuming only one paging carrier for a specific coverage level is too restricted.  For Option 1c, we assume the legacy calculation of the PF, i\_s, PNB, wg, and the (final determination of) NB-IoT paging carrier can be reused (as much as possible). Compared with the legacy scheme, the main difference is that a new carrier list (CEL-based paging carrier list) would be used instead of the legacy carrier list. Therefore, we see no clear motivation to exclude the use of this paging weight parameter for R17 paging carrier selection.  The related changes may be very similar as that for GWUS support. For example, one of the possible change might be as following :  *-* W: Total weight of all NB-IoT paging carriers, i.e. W = W(0) + W(1) + … + W(Nn-1). If UE monitors GWUS according to clause 7.5.1, Total weight of all NB-IoT paging carriers configured with GWUS. If UE selects paging carrier based coverage enhanced level and UE does not monitor GWUS according to clause 7.5.1, W is the total weight of all NB-IoT paging carriers configured within *PCCH-Config-NB-r17* and with the value of *npdcch-NumRepetitionPaging-r17* that is equal to the *npdcch-NumRepetitionPaging-r17* assigned to UE; If UE selects paging carrier based coverage enhanced level and UE monitors GWUS according to clause 7.5.1, W is the total weight of all NB-IoT paging carriers configured within *PCCH-Config-NB-r17* andwith the value of *npdcch-NumRepetitionPaging-r17* that is equal to the *npdcch-NumRepetitionPaging-r17* configured to UE, and configured with GWUS. |
| Ericsson | Yes |  |
| Huawei, HiSilicon | yes |  |
| Qualcomm | No | We don’t think it is too restrictive to have one or two coverage-based paging carriers per coverage level and for that reason adding weighting factor is just over complicating for no real field benefit. How may paging carriers are used in real networks today? |
| MediaTek | Yes |  |

**Conclusion:**

### Mixed operation

In [R2-2110695], company mentioned that in legacy signaling, up to two downlink non-anchor carrier lists can be broadcasted if cell supports mixed operation mode, e.g., *dl-ConfigList-r14* list and *dl-ConfigListMixed-r15.* Only a UE that supports *mixedOperationMode* is required to use the *dl-ConfigListMixed-r15* in addition to the *dl-ConfigList-r14*.

Company further think that coverage-based paging carrier selection should be possible to use by a UE without the need to support *mixedOperationMode*. And company suggest that coverage-based paging carrier configuration shall be separate for non-mixed operation mode and for mixed operation mode. Only a UE supporting *mixedOperationMode* and coverage-based paging carrier selection is required to use mixed operation mode coverage-based configuration.

**Q2-08: Do companies agree that coverage-based paging carrier configuration shall be separate for non-mixed operation mode and for mixed operation mode?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We agree that coverage-based paging carrier selection should be possible to use by a UE without the need to support *mixedOperationMode*.  Therefore, the R17 UEs with different mixed operation capabilities may finally maintain different CEL-based paging carrier lists. But this does not necessarily mean that two carrier lists configuration need to be introduced in R17. |
| Ericsson | Yes |  |
| Huawei, HiSilicon | FFS | Not sure I understand the question. We agree that it should also be supported with mixed operation mode. |
| Qualcomm | Yes |  |
| MediaTek | Yes |  |

**Conclusion:**

### Which SIB

**Q2-09: Companies are invited to provide your choice on the following alternatives for providing the configuration of R17 carrier list?**

* **Alt1: Extension in SIB22-NB**
* **Alt2: A new SIB**
* **Alt3: Other**

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| --- | --- | --- |
| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 | Generally, as we assume the total number of paging carriers for R17 and R17 earlier in SIB configuration would not exceed 16, we think it’s feasible and enough to extend SIB22-NB to include R17 paging carrier list configuration. |
| Ericsson | Alt1 |  |
| Huawei, HiSilicon | Alt1 | Alt 1 is definitively the simplest and we think sufficient. But again, thinking that we can configure 15 paging carriers in SIB22 is not realistic. |
| Qualcomm | Alt3 | It depends on the size of R17 extension. First conclude on how many coverage levels to support and what information to signal then decide whether it can fit in SIB22-NB or a new SIB is needed. |
| MediaTek | Alt1 | Although we prefer to expand in SIB22-NB, the number of carriers should be discussed ahead. |

**Conclusion:**

### ASN.1 example

In [R2-2110110], one example for R17 carrier list configuration is given as following:

**Alt1:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *SystemInformationBlockType22-NB* information element  -- ASN1START  SystemInformationBlockType22-NB-r14 ::= SEQUENCE {  dl-ConfigList-r14 DL-ConfigCommonList-NB-r14 OPTIONAL, -- Need OR  ul-ConfigList-r14 UL-ConfigCommonList-NB-r14 OPTIONAL, -- Need OR  // omit the unchanged part//  }  DL-ConfigCommonList-NB-r14 ::= SEQUENCE (SIZE (1.. maxNonAnchorCarriers-NB-r14)) OF  DL-ConfigCommon-NB-r14  UL-ConfigCommonList-NB-r14 ::= SEQUENCE (SIZE (1.. maxNonAnchorCarriers-NB-r14)) OF  UL-ConfigCommon-NB-r14  UL-ConfigCommonListTDD-NB-r15 ::= SEQUENCE (SIZE (1.. maxNonAnchorCarriers-NB-r14)) OF  UL-ConfigCommonTDD-NB-r15  DL-ConfigCommon-NB-r14 ::= SEQUENCE {  dl-CarrierConfig-r14 DL-CarrierConfigCommon-NB-r14,  pcch-Config-r14 PCCH-Config-NB-r14 OPTIONAL, -- Need OR  ...,  [[ wus-Config-r15 WUS-ConfigPerCarrier-NB-r15 OPTIONAL -- Cond WUS  ]],  [[ gwus-Config-r16 WUS-ConfigPerCarrier-NB-r15 OPTIONAL -- Cond GWUS  ]],  [[ pcch-Config-r17 PCCH-Config-NB-r17 OPTIONAL -- Cond pcch-Config-r14  ]]  }  PCCH-Config-NB-r14 ::= SEQUENCE {  npdcch-NumRepetitionPaging-r14 ENUMERATED {  r1, r2, r4, r8, r16, r32, r64, r128,  r256, r512, r1024, r2048,  spare4, spare3, spare2, spare1} OPTIONAL, -- Need OP  pagingWeight-r14 PagingWeight-NB-r14 DEFAULT w1,  ...  }  PCCH-Config-NB-r17 ::= SEQUENCE {  npdcch-NumRepetitionPaging-r17 ENUMERATED {  r1, r2, r4, r8, r16, r32, r64, r128,  r256, r512, r1024, r2048,  spare4, spare3, spare2, spare1} OPTIONAL, -- Need OP  pagingWeight-r17 PagingWeight-NB-r14 DEFAULT w1,  defaultPagingCyclePerRmax-r17 ENUMERATED {rf32, rf64, rf128, rf256, rf512, rf1024} OPTIONAL, -- Need OR  nB-PerRmax-r17 ENUMERATED {  fourT, twoT, oneT, halfT, quarterT, one8thT,  one16thT, one32ndT, one64thT,  one128thT, one256thT, one512thT, one1024thT,  spare3, spare2, spare1} OPTIONAL, -- Need OR  ...  }  PagingWeight-NB-r14 ::= ENUMERATED {w1, w2, w3, w4, w5, w6, w7, w8,  w9, w10, w11, w12, w13, w14, w15, w16}  // omit the unchanged part//  -- ASN1STOP   |  | | --- | | *SystemInformationBlockType22-NB field descriptions* | | *…………..* | | ***pcch-Config***  Configure the PCCH parameters for the non-anchor DL carrier.  If pcch-Config-r17 is configured in a cell, the UE supporting Coverage Enhanced Level based paging carrier selection will only select the carrier with pcch-Config-r17 configured for paging. The UE not supporting Coverage Enhanced Level based paging carrier selection does not select the carrier with pcch-Config-r17 configured for paging. |  |  |  | | --- | --- | | Conditional presence | Explanation | | *pcch-Config-r14* | This field is optionally present, Need OR, if the field pcch-Config-r14 is absent. Otherwise the field is not present. | |

In [R2-2110695], another example for R17 carrier list configuration is given as following:

Alt2:

-- ASN1START

SystemInformationBlockType22-NB-r14 ::= SEQUENCE {

dl-ConfigList-r14 DL-ConfigCommonList-NB-r14 OPTIONAL, -- Need OR

ul-ConfigList-r14 UL-ConfigCommonList-NB-r14 OPTIONAL, -- Need OR

pagingWeightAnchor-r14 PagingWeight-NB-r14 OPTIONAL, -- Cond pcch-config

nprach-ProbabilityAnchorList-r14 NPRACH-ProbabilityAnchorList-NB-r14 OPTIONAL, -- Cond nprach-config

lateNonCriticalExtension OCTET STRING OPTIONAL, ...,

[[ mixedOperationModeConfig-r15 SEQUENCE {

dl-ConfigListMixed-r15 DL-ConfigCommonList-NB-r14 OPTIONAL, -- Cond dl-ConfigList

ul-ConfigListMixed-r15 UL-ConfigCommonList-NB-r14 OPTIONAL, -- Cond ul-ConfigList

pagingDistribution-r15 ENUMERATED {true} OPTIONAL, -- Need OR

nprach-Distribution-r15 ENUMERATED {true} OPTIONAL -- Need OR

} OPTIONAL, -- Need OR

ul-ConfigList-r15 UL-ConfigCommonListTDD-NB-r15 OPTIONAL -- Cond TDD

]],

[[ dl-ConfigListWithCoverage-v17xy DL-ConfigCommonList-NB-v17xy OPTIONAL, -- Need OR

dl-ConfigListMixedWithCoverage-v17xy DL-ConfigCommonList-NB-v17xy OPTIONAL -- Need OR

]]

}

--- other existing IEs omitted ----

DL-ConfigCommonList-NB-v17xy ::= SEQUENCE (SIZE (1.. maxNonAnchorCarriers-NB-r14)) OF DL-ConfigCommon-NB-r17

--- other existing IEs omitted ----

DL-ConfigCommon-NB-r17 ::= SEQUENCE {

dl-CarrierConfig-r17 DL-CarrierConfigCommon-NB-r14 OPTIONAL, -- Need OR

pcch-Config-r17 PCCH-Config-NB-r17 OPTIONAL, -- Need OR

wus-Config-r15 WUS-ConfigPerCarrier-NB-r15 OPTIONAL, -- Cond WUS

gwus-Config-r16 WUS-ConfigPerCarrier-NB-r15 OPTIONAL, -- Cond GWUS

...

}

PCCH-Config-NB-r17 ::= SEQUENCE {

carrierSpecificPagingCycle-r17 ENUMERATED {rf32, rf64, rf128, rf256, rf512, rf1024, spare2,

spare1}, OPTIONAL -- Need OP

carrierSpecific-nB-r17 ENUMERATED {fourT, twoT, oneT, halfT, quarterT, one8thT, one16thT,

one32ndT, one64thT, one128thT, one256thT, one512thT,

one1024thT, spare3, spare2, spare1}, OPTIONAL -- Need OP

npdcch-NumRepetitionPaging-r17 ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128, r256, r512,

r1024, r2048, spare4, spare3, spare2, spare1},

carrierSpecificCoverageLevel-r17 RSRP-Range,

...

}

**Q2-10: Companies are invited to give your preference on the following ASN.1 example alternatives. The choice might be used as the start point for further stage-3 discussion. No matter what the answer is, companies can further provide some high level suggestions on the ASN.1:**

* **Alt1**
* **Alt2**
* **Alt3 (Other)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Preferred alternative** | **Additional comment(s)** |
| ZTE | Alt1 | We think Alt1 has less signaling overhead. And with Alt1, the *dl-ConfigList-r14* and *dl-ConfigListMixed-r15* can be used as legacy.  For Alt2, we worry about that, if new carrier lists are introduced, there may have impact on the description for determining the *npdcch-CarrierIndex* in NPRACH resource.  In Alt1, the coverage specific *ue-SpecificDRX-CycleMin* andcoverage specific NRSRP criteria/threshold (see our comments for **Q3-02**) are missing in PCCH-Config-NB-r17.  In Alt1, the parameter *npdcch-NumRepetitionPaging*, default Paging Cycle and *nB* are currently configured per carrier, we assume additional restriction would be mentioned if we agree they should be coverage specific. Based on Alt1, one example for configuring coverage specific parameters can be as following:  SystemInformationBlockType22-NB-r14 ::= SEQUENCE {  // omit the unchanged part//  ul-ConfigList-r15 UL-ConfigCommonListTDD-NB-r15 OPTIONAL -- Cond TDD  ]],  [[ PCCH-ConfigList-NB-r17 ::= SEQUENCE (SIZE(1..maxRmaxNumber-NB-r17)) OF PCCH-Config-NB-r17 OPTIONAL, -- Need OR  ]]  }  // omit the unchanged part//  DL-ConfigCommon-NB-r14 ::= SEQUENCE {  // omit the unchanged part//  [[ gwus-Config-r16 WUS-ConfigPerCarrier-NB-r15 OPTIONAL -- Cond GWUS  ]],  [[ PCCH-ConfigIndex-r17 INTEGER(1..maxRmaxNumber-NB-r17) OPTIONAL -- Cond PCCH-Config-r14  ]]  }  PCCH-Config-NB-r14 ::= SEQUENCE {  // omit the unchanged part//  }  PCCH-Config-NB-r17 ::= SEQUENCE {  npdcch-NumRepetitionPaging-r17 ENUMERATED {  r1, r2, r4, r8, r16, r32, r64, r128, r256, r512, r1024,  r2048, spare4, spare3, spare2, spare1} OPTIONAL, -- Need OP  pagingWeight-r17 PagingWeight-NB-r14 DEFAULT w1,  defaultPagingCycle-r17 ENUMERATED {rf32, rf64, rf128, rf256, rf512, rf1024} OPTIONAL, -- Need OR  ue-SpecificDRX-CycleMin-r17 ENUMERATED {rf32, rf64, rf128, rf256, rf512, rf1024} OPTIONAL, -- Need OR  nB-r17 ENUMERATED {  fourT, twoT, oneT, halfT, quarterT, one8thT,  one16thT, one32ndT, one64thT, one128thT,  one256thT, one512thT, one1024thT,  spare3, spare2, spare1} OPTIONAL, -- Need OR  rsrpThreshold-r17 RSRP-Range,  ...  }  // omit the unchanged part// |
| Ericsson | Alt1 |  |
| Huawei, HiSilicon | FFS | We think there are two main approaches:  1: extend DL-ConfigCommon-NB-r14.  This has the benefit of being simple and similar to what we have today, thus limiting the impact on the specification (not only the signaling but also the description of the mechanism, e.g. for mixed operation mode). However we think the same should be achievable with new lists.  2. Create new carriers lists  This has the benefit of reducing the signaling overhead in the configuration of the R17 carriers by removing the extension markers.  Before deciding which way to go, it would be beneficial to understand how these lists are organized w.r.t to ‘coverage level’ |
| Qualcomm | Alt3 | First conclude on the following before discussing detailed signaling:   * what needs to be signaled * whether there needs to be separate list for mixed mode carrier   whether the information can fit into existing SIB(s). |
| MediaTek | Alt2 | For Alt1, the legacy UE will omit the PCCH-ConfigIndex-r17 and treat this paging carrier as a legacy carrier. |

**Conclusion:**

## Determining suitability of assigned Rmax and paging carrier selection

### NRSRP threshold

RAN2 has agreed UE metric for determining carrier suitability and selection is based on NRSRP.

In [R2-2110149], company suggest each group of Rel-17 paging carriers can be configured with a NRSRP threshold value to enable coverage-based paging carrier selection for fallback scenarios (e.g., when coverage level changes). In the fallback scenario, UE selects the paging carrier based on the estimated RSRP value from idle mode measurements against the configured threshold value. During email discussion [AT116-e][304] ([R2-2111394]), some other companies mentioned similar thoughts, e.g., the UE checks its serving NRSRP vs the threshold corresponding to its assigned CEL, and if suitable, selects a carrier in the list of carrier corresponding to its assigned CEL.

Per rapporteur’s understanding on the mentioned contributions and previous discussion, a simple way for determining suitability of assigned Rmax and selecting R17 paging carrier might be summarized as following:

* NRSRP criteria/threshold can be provided by network and one Rmax (*npdcch-NumRepetitionPaging*) maps to one and only one NRSRP criteria/threshold.
* UE compares its serving cell NRSRP with the NRSRP criteria/threshold which is corresponding to UE’s assigned Rmax (*npdcch-NumRepetitionPaging*):
  + If UE’s serving cell NRSRP is equal to or higher (better) than the NRSRP criteria/threshold, the UE can determine its coverage doesn’t change worse. UE can keep using the assigned Rmax and select a R17 carrier in the carrier list corresponding to this assigned Rmax.
  + Otherwise (e.g., UE’s serving cell NRSRP is below the NRSRP criteria/threshold), the UE fallback to legacy carrier selection scheme.

**Q3-01: Do companies agree to take the above way as baseline for determining suitability of assigned Rmax and paging carrier selection? If the answer is “No”, please indicate the main difference in your thinking.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | Fine with such basic way and further details can be discussed. A hysteresis or filter parameter may be additionally applied when performing comparison, as mentioned in below discussion. |
| Ericsson | Yes as baseline |  |
| Huawei, HiSilicon | No | We think we could have a similar approach to the NPRACH resources, i.e. the NW signals the thresholds in SIB, each threshold maps to a least of equivalent carriers. The UE is assigned a “coverage level” via dedicated ignaling. If its measured NRSRP matches the thresholds for its assigned coverage level, it selects a carrier in the corresponding list. If not, the UE uses the legacy scheme.  In other words, we do not see the role of Rmax in the selection criteria. |
| Qualcomm | No | Without hysteresis the fallback can lead to ping-pong between two paging carriers and result in missed paging. |
| MediaTek | Yes |  |

**Conclusion:**

During previous email discussion, some companies have mentioned such NRSRP criteria/threshold can be provided in SIB, e.g., corresponding to a coverage level (Rmax/*npdcch-NumRepetitionPaging*).

In [R2-2111394], company has mentioned another way. They do not think there is a need to assign a NRSRP value (threshold) per R17 paging carrier in system information broadcast, however such value should be provided to the UE when it is released to idle along with an hysteresis mechanism so that the UE can determine whether its coverage situation has changed since it was released to idle. E.g., if the UE measures an NRSRP value lower than the configured value for longer than hysteresis, it should consider itself in worse coverage than what network assumed during release and performs fallback.

Per rapporteur’s understanding, if NRSRP criteria/threshold is provided in RRC release message, it is UE specific and one-to-one mapping to the assigned Rmax. UE can directly compare its serving cell NRSRP with this NRSRP criteria/threshold. If NRSRP criteria/threshold is provided in SIB, UE needs to firstly determine a NRSRP criteria/threshold in SIB which is corresponding to UE’s assigned Rmax.

**Q3-02: Companies are invited to indicate your preference on how to provide NRSRP criteria/threshold:**

* **Alt1: NRSRP criteria/threshold is provided in SIB and is coverage specific, which means a common NRSRP criteria/threshold value is configured to the R17 paging carriers with same *npdcch-NumRepetitionPaging***
* **Alt2: NRSRP criteria/threshold is provided when UE is released to idle**
* **Alt3: Other**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Alt1 | We think Alt1 is enough and simple.  For Alt2, for same assigned Rmax, NRSRP criteria/threshold can be different for different Ues. It’s a bit more flexible but no clear benefit can be seen. And signaling overhead would increase. |
| Ericsson | FFS, ALT3 | Both options can be realized Alt 1, Alt2 |
| Huawei, HiSilicon | alt3 | We agree with signaling in SIB but we do not agree with the rest of the description.  See our answer to Q3-01 |
| Qualcomm | Alt1 | NRSRP applicable to coverage-based paging carrier(s) is a property of the paging carrier(s) hence should be provided in SIB. |
| MediaTek | Alt1 |  |

**Conclusion:**

### Hysteresis/longer averaging/timer for UE metric

RAN2 has agreed to use a hysteresis/longer averaging/timer for UE metric based on NRSRP. Details are FFS.

In [R2-2111394], company mentions that UE can determine whether its coverage situation has changed since it was released to idle. E.g., if the UE measures an NRSRP value lower than the configured value for longer than hysteresis. In [R2-2110694], company also mentions that hysteresis is needed to avoid frequent switching between paging carriers. This is so that UE does not switch paging carrier just based on one or two NRSRP measurements. In [R2-2110475], company mentions that the UE switches to the R17 carrier if the NRSRP is better than the configured threshold during 5 mn or one eDRX cycle if longer. Per rapporteur’s understanding, companies mentions a similar way to use a “hysteresis”. But this may be more like a filtering scheme, e.g., to compare NRSRP with the configured threshold over a period.

**Q3-03: Do companies agree that a fixed (e.g., one eDRX cycle) or a configurable “hysteresis”, e.g., a timer period can be applied when UE compares its serving cell NRSRP with the NRSRP criteria/threshold?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We agree it’s beneficial to let the suitability checking based on NRSRP continue for a time period to ensure a stable evaluation result.  Such time period can be fixed. It’s simple. It’s also acceptable to us to configure such time period along with the NRSRP criteria/threshold in SIB. |
| Ericsson |  | We can leave it to UE implementation on how to implement filter the measurements and duration for hysteresis |
| Huawei, HiSilicon | yes | The UE shall only use the r17 carrier if the NRSRP criteria has been verified for a certain amount of time. We think the duration depends on how frequently the UE performs measurements, thus depends on the DRX cycle length |
| Qualcomm | No | It is difficult to predict what the actual deployments would look hence we don’t think a fixed value can work for all cases just as coverage level is not fixed. The hysteresis has to be longer than one DRX cycle and it should be a cell configurable parameter. |
| MediaTek | No | It can be left to UE implementation. |

**Conclusion:**

In [R2-2110694], company mentions another kind of hysteresis, e.g., a hysteresis similar to that applied to serving cell that can prevent frequent switching between different paging carriers. But such hysteresis will cause the UE to ‘stick’ to the selected paging carrier for longer period. Company further indicate negative impact on paging performance due to hysteresis can be minimized by ensuring there is reasonable headroom e.g., the coverage-based paging carrier can still be usable when the serving cell is 6dB lower than the required coverage level to select the paging carrier. Larger the headroom, the lower the benefit of coverage-based paging carrier.

Per rapporteur’s understanding, here company suggest an “offset” (headroom) to the NRSRP criteria/threshold.

**Q3-04: Do companies agree to further apply an “offset” (headroom) to the configured NRSRP criteria/threshold?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | No | We cannot see clear benefit of such “offset” (headroom).  If network can assume such “offset”, network can directly apply this offset to the previous “absolute” NRSRP criteria/threshold when configure it. E.g., network may originally wanted to set NRSRP criteria/threshold to -110dB, if it can assume an offset 6dB, network can directly configure NRSRP criteria/threshold to -116dB.  Moreover, we don’t think a hysteresis similar to that applied to serving cell is needed. The possible way of such hysteresis may be to apply two different NRSRP criteria/thresholds for switching from R17 carrier to legacy carrier and switching from legacy carrier to R17 carrier. We think the intention of reducing ping-pong may be not so clear.  In this R17 paging carrier selection, the main point should be to keep consistent paging carrier selection between UE and network. Therefore, before each PO, it’s more important to guarantee UE can try to keep using the R17 carrier determined by the assigned Rmax (as network would start paging on this carrier). We think an “absolute” NRSRP criteria/threshold is enough and a conservative configuration for this NRSRP criteria/threshold in SIB would be helpful.  The only issue we can see may be that during paging retransmission, e.g., UE already fallback to a legacy paging carrier, if later UE is quickly back to R17 paging carrier because radio quality change better, it seems UE may miss the paging. However, as we can assume network may send paging on both R17 paging carrier and legacy paging carrier when it retransmit the paging (a possible network implementation strategy to handle CEL change case), this issue can be naturally resolved. |
| Ericsson |  | We can leave it to UE implementation on how to implement filter the measurements and duration for hysteresis |
| Huawei, HiSilicon | No | We think that the NW can be conservative in the setting of the threshold, no need for an additional configurable offset |
| Qualcomm | No | No, additional headroom is not necessary as this should be take care of by selection of Rmax for the coverage level. |
| MediaTek | No |  |

**Conclusion:**

In [R2-2110475], company further mentions an adaptation of the cell reselection principle, e.g., the UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier. Also, it seems preferable that the UE does not switch carrier within a PTW as this may have impact on the paging escalation mechanism.

**Q3-05: Do companies agree to introduce a “restriction” that the UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier or within a PTW?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Maybe No? | As our comments for **Q3-04**, before each PO, UE would perform suitability checking of assigned Rmax and paging carrier selection. It’s more important to guarantee UE can try to keep using the R17 carrier determined by the assigned Rmax (as network would start paging on this carrier). A conservative configuration for NRSRP criteria/threshold in SIB would be helpful, e.g., as long as the coverage is not too bad, UE could continue to use the selected R17 paging carrier.  We guess the proposed scheme in [R2-2110475] may be to let UE wait for a time period before performing suitability checking? We cannot see the necessity but worry about the complexity. Or maybe this can be purely left to UE implementation. |
| Ericsson | No or up to UE implementation |  |
| Huawei, HiSilicon | yes | We think switching at each PO is contradicting Q3-03 i.e. the need for the criteria to have been fulfilled for long enough |
| Qualcomm | Yes | Hysteresis effectively introduces a minimum period UE remains on one paging carrier. As the purpose of PTW was to overcome issues such as (i) UE fails to decode page due to short term fading, (ii) RAN unable to page UE in some Pos due to congestion, we think it is correct for UE to use the same paging carrier during the PTW. |
| MediaTek | Yes | If UE can switch carriers at any time, it has a good chance to miss the paging occasion. To avoid that, it is better to wait for at least a paging cycle before switch to another paging carrier. |

**Conclusion:**

## UE report

RAN2 still FFS whether to introduce new UE report and/or whether to mandate support of existing Msg5 reporting.

In [R2-2110694], per rapporteur’s understanding, company suggests UE can consider the measured NRSRP over many paging occasions (over longer period than 10s of seconds?) and determine an initial threshold for coverage-based paging carrier selection. UE can further determine a coverage-based paging carrier compatible with the measurement (and the initial threshold?) and report the index of this paging carrier to the network. Furthermore, network indicates to the UE whether it is allowed to use this coverage-based paging carrier that the UE indicates to the network.

In [R2-2110475], company mentions that UE report of its ‘preferred’ paging carrier does not bring any benefit compared to the reporting of the coverage status of the UE as any UE selection will be based on either NRSRP or estimated Rmax. In addition, the eNB may want to be a bit conservative or take other information into account (e.g. interferences on the downlink carriers) in the configuration of the selection criteria. Therefore, company think it’s no need to introduce new UE reporting to assist in the configuration of the paging carrier selection criteria.

In [R2-2109912] and [R2-2111113], companies think Msg5 based reporting (e.g., NRSRP and NRSRQ of serving cell measurement result in Msg5) can be reused or can be made mandatory.

**Q4: Do companies agree not to introduce UE report for a preferred/selected coverage-based paging carrier? If Yes, that means at least existing Msg5 reporting can be re-used. Companies can further indicate whether to make the report in Msg5 mandatory.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | No | We have sympathy with the analysis in [R2-2110475] and cannot see the obvious benefit of such UE report for a preferred/selected coverage-based paging carrier. We think suitable NRSRP criteria/threshold configuration in SIB and network implementation strategy for paging retransmission can be helpful enough.  We are fine to make the legacy Msg5 report mandatory. But just note this is no use in EDT and PUR procedure (we assume Msg4 in EDT or PUR procedure can also be used to assign Rmax information to UE). |
| Ericsson | Yes | In order to provide suitable Rmax value the NW will need measurement report from UE. |
| Huawei, HiSilicon | ? | unclear question  We do not see the need for the UE to indicate a preferred carrier. How does the UE know this if it is not monitoring this carrier.  We think that the NW knowing the UE measured NRSRP is helpful. |
| Qualcomm | May be | The main concern raised in R2-2110475 is that NRSRP is a very short-term measurement, as such this is not sufficient to make long-term decisions. Remember the existing serving cell measurement report was aimed for ANR/SON and ANR/SON would typically use many (100s) reports to make any system level adjustments. Even if it is used for link management it only impacts the resources used for the current RRC connection and does not directly impact future idle or connected mode behavior. Therefore, existing report is not suitable for eNB to decide suitable Rmax.  If the existing signalling for the serving cell report can be used but with the ability for the UE to indicate whether this report is suitable for coverage-based paging carrier selection. The eNB should only provide information to the UE for the coverage-based paging carrier (e.g., Rmax, or NRSRP or carrier index) in dedicated signalling if UE has indicated the measurement report is suitable for coverage-based paging carrier selection. |
| MediaTek | Yes | UE report can help NW to configure paging carrier selection |

**Conclusion:**

## Other aspects

**Q5: Any other details need to be addressed/clarified?**

|  |  |
| --- | --- |
| **Company** | **Additional comment(s)** |
|  |  |
|  |  |
|  |  |

**Conclusion:**

# Conclusion

**TBD**

# References

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[10] R2-2111113, Discussion on details of paging carrier selection options, MediaTek Inc., RAN2#116e

[11] R2-2111394, Report of [AT116-e][304][NBIOT/eMTC] NB-IoT carrier selection, ZTE Corporation, RAN2#116e