**3GPP TSG-RAN WG2 Meeting #117 electronic  *R2-220xxxx***

**Online, Feb 21st – Mar 3rd 2022**

**Agenda item: 9.1.2**

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

**Title: Report of [Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)**

**Document for: Discussion and Decision**

# Introduction

This document is the report of the offline email discussion “*[Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)*”, as indicated below:

* *[Pre117-e][301][NBIOT/eMTC R17] NB-IoT carrier selection (ZTE)*

***Deadline:*** *Monday 2022-02-14 23:59 UTC.*

The document would collect structured company inputs and give proposals for the open issues of the coverage level-based paging carrier selection topic in R17 NB-IoT.

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# Discussion

The agreements achieved in RAN2#116bis e-meeting are listed below for reference:

|  |
| --- |
| **Agreements [Online]**   * *UE can be enabled/disabled coverage-based paging carrier selection via dedicated signalling. Presence or absence of the coverage information can be implicit enable/disable indication.* * *In SIB, the value range for Rmax (npdcch-NumRepetitionPaging) in R17 paging carrier (list) configuration can be ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128}.* * *In SIB, coverage specific nB is supported, e.g., a common nB value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging).* * *Coverage-specific default DRX cycle is not supported.* * *Working assumption: In SIB, coverage specific ue-SpecificDRX-CycleMin is supported, e.g., a common ue-SpecificDRX-CycleMin value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging).*   + *(FFS check whether there are any issues with the UE specific minimum DRX cycle per coverage level, can confirm WA if no issues.)* * *Paging weight can still be used in coverage-based paging carrier selection.* * *In SIB, both non-mixed operation mode and mixed operation mode can be supported in R17 paging carrier list configuration. They can be configured separately (as legacy).* * *The extension in SIB22-NB can be used for providing R17 paging carrier list configuration.* * *No “offset” (headroom) would be introduced for the configured NRSRP threshold.* * *A configurable cell specific timer period can be applied when UE compares its serving cell NRSRP with the NRSRP threshold. FFS how to signal and value range.* * *It’s specified that UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier or within a PTW. FFS value of [xx] seconds* * *Coverage based paging carrier selection is enabled implicitly, i.e., when relevant parameters are provided to the UE during release.* * *The Rel-17 paging carriers can also be used as the DL carriers for random access.* * *No need to introduce a subgroup of paging carriers for the more easily changed CE level.* * *In SIB, at most 2 coverage levels can be configured in R17 paging carrier list, each coverage level has one NRSRP threshold* * *Rmax may be configured per carrier or per carrier group (coverage level).* * *A paging carrier group index, e.g., the index to one of the two lists which correspond to the 2 coverage levels in SIB, is provided to the UE in dedicated signaling (when UE is released to idle).* * *UE measured NRSRP can be reported to network for assisting the network to provide suitable coverage level related information. FFS how.* * *FFS whether to introduce a new paging carrier list, e.g., DL-ConfigCommon-NB-r17, or just to extend PCCH-ConfigList-NB.* * *FFS whether to send LS to RAN3 (at the start of the next meeting)* |

## Open Issue 1: UE specific minimum DRX cycle

During “*[Post116-e][311] NB-IoT carrier selection* (R2-2200030)” email discussion, this issue has been discussed in details. Based on companies’ inputs, a proposal is given that “*In SIB, coverage specific ue-SpecificDRX-CycleMin is supported*”.

During the online discussion in RAN2#116bise, some companies are not sure whether coverage specific *ue-SpecificDRX-CycleMin* is needed. Moreover, in the 36.331 running CR under discussion (“*[Post116-e][316]*”), based on the company’s contribution, a kind of carrier specific parameter, e.g., *carrier-SpecificDRX-CycleMin-r17* has been mentioned in the ASN.1.

**Q1: Companies are invited to provide your preference on the following options for UE specific minimum DRX cycle and please elaborate the reasons for your choice (Please note the exact naming can be discussed later):**

* **Option 1:** to introducea new *ue-SpecificDRX-CycleMin* which is configured per coverage level
* **Option 2:** to introduce a new *ue-SpecificDRX-CycleMin* which is configured per R17 paging carrier
* **Option 3:** no new parameter for *ue-SpecificDRX-CycleMin*. That mean legacy cell specific*ue-SpecificDRX-CycleMin* would be used.

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| --- | --- | --- |
| **Company** | **Option** | **Comment** |
| ZTE | Option 1 | According to TS 36.304, the usage of *ue-SpecificDRX-CycleMin* in R16 is that: T = min (default DRX value, max (UE specific DRX value, minimum UE specific DRX value broadcast in system information)).  Per our understanding, the configuration of *ue-SpecificDRX-CycleMin* can be smaller than the default DRX cycle of the cell and it need to be consistent with the paging resources density and the maximum paging repetitions of the cell:   * For a UE with small UE specific DRX value, in order to avoid CSS overlapping, the UE specific DRX value may not be directly used for T calculation. The small UE-specific DRX cycle needs to be "corrected" by such process that max (UE specific DRX value, minimum UE specific DRX value broadcast in system information). This would result in that, in some cases, the small UE specific DRX cycle is no longer used and *ue-SpecificDRX-CycleMin* would be used to compare with other cycles. In this way, CSS overlapping can be avoided.   After CEL-based paging carrier selection is supported, at most two R17 paging carrier groups (corresponding to two coverage levels) would be configured which are assumed to be used by UE in good or middle coverage situation. We have agreed that, for each paging carrier group corresponding to each coverage level, the carriers in it can have a common *nB* value configuration. That means, these carriers could be configured with denser paging resources, less repetitions and therefore can accommodate more pagings. Therefore, we think a coverage specific *ue-SpecificDRX-CycleMin* is needed which can be adapted to the paging resource density and the paging repetitions of each paging carrier group. We see no necessity or benefit to provide carrier specific *ue-SpecificDRX-CycleMin.*  DuringRAN2#116bise discussion, company has mentioned this parameter is not needed as it cannot be known by core network, hence CN’s paging strategy may not take full advantage of UE specific DRX cycle. We are not so sure about the issue (even if there is an issue, it exists from R16). We think core network anyway can send a paging to the eNB, mainly according to the actual arrival of the DL service and the paging cycles it knows about. The main usage of *ue-SpecificDRX-CycleMin* is in eNB, e.g., for optimized scheduling of paging in air interface. Therefore, it has no intention to let core network know this information. The only possible issue may be that eNB may need to cache some pagings for a while. We think this is acceptable in the case that required repetitions are large. |
| **Qualcomm** | Option 1 | Don’t see a major use-case to have a carrier specific minimum DRX cycle hence a coverage specific DRX cycle is sufficient.  We also propose to limit the value range to 320, 640, 1280 and 2560ms. |
| **Huawei, HiSilicon** | Option 1 | We agree that the issue exists in R16, i.e. the CN does not know via S1/NG-AP what is the minimum UE specific DRX supported in the cell and whether it is supported at all, still this van be known via OAM. If the MME does not know, then it may retransmit paging too early, possibly even before the first page has been delivered.  If we have UE specific DRX min per carrier in R717, in the MME does not know, this is kind if improvement to R16. If the MME knows by OAM, then the UE may monitor more that needed, but this is not a big issue. |
| **NEC** | Option 2 | In previous meeting we agreed that Rmax may be configured per carrier or per carrier group (coverage level), so at least the granularity of ue-SpecificDRX-CycleMin should align to Rmax.  The main difference between option 1 and option 2 is that option 2 allow carriers belong to a same coverage level having different ue-SpecificDRX-CycleMin. So the choice between option 1 and 2 depends on whether one coverage level is correspond to a range of Rmax value or just one Rmax value. We think option 2 can achieve more flexible configuration for a carrier group (coverage level) consists of more than one carriers. |
| **Spreadtrum** | Option 1 | The paging related parameters (e.g., DRX cycle, npdcch-NumRepetitionPaging, CE level) are interconnected, and the parameter npdcch-NumRepetitionPaging is strongly correlated to enhanced coverage level. That is, the good coverage usually needs to be configured with small npdcch-NumRepetitionPaging. The UE with good coverage can be allowed to use a smaller *ue-SpecificDRX-CycleMin*. For the same reason, the UE with bad coverage can be allowed to use a larger *ue-SpecificDRX-CycleMin.*  In order to handle the issue of CSS overlapping, a coverage specific *ue-SpecificDRX-CycleMin* should be applied. |
| **Nokia** | Option 1 | Coverage level specific repetition values allows the UE in normal coverage to use lower UE specific DRX values in this coverage level. As the carriers are grouped and selected based on coverage level, it is simple to keep the UE-Min-DRX cycle is also configured for the group. Having this parameter at carrier specific further makes the carrier selection complicated with one more level of selection based on min-DRX value of carrier. |
| **Ericsson** | Option 1 |  |
| **MediaTek** | Option 1 | The coverage based *ue-SpecificDRX-CycleMin* can allow UE to be configured with the most suitable DRX cycle without causing CSS overlapping issue. The carrier based scheme seems unnecessary complicated. |
| **Sequans** | Option 1 | Coverage-specific is enough |

**Summary:**

9 companies provided views to Q1:

* 8 companies prefer **Option 1**, e.g., to introducea new *ue-SpecificDRX-CycleMin* which is configured per coverage level.
* 1 companies prefer **Option 2**, e.g. a new carrier specific *ue-SpecificDRX-CycleMin* which is configured per R17 paging carrier.

Following the majority views, the proposal is given as below:

**Proposal 1: RAN2 introduces a new *ue-SpecificDRX-CycleMin* parameter which is configured per coverage level.**

## Open Issue 2: Time duration for UE staying on a paging carrier

RAN2 has agreed “*UE does not switch paging carrier if it has stayed less than [xx] seconds on the carrier or within a PTW*”. Not only the value of [xx] seconds but also the details of UE behavior need to be further discussed and decided.

**Q2a: Companies are invited to provide comments on whether the UE needs to wait [xx] seconds or skip paging carrier switching in PTW in both of the following cases or in only one case:**

* + **Case 1: After selecting R17 paging carrier**
  + **Case 2: After fallback to legacy paging carrier**

|  |  |  |
| --- | --- | --- |
| **Company** | **Case** | **Comment** |
| ZTE | Only Case 1 | We think the main purpose of introducing [xx] seconds or skipping paging carrier switching in PTW is try to avoid ping-ping between different paging carriers and try to reduce the inconsistence between UE and network. So it’s acceptable to us to keep the UE on the selected R17 paging carrier for a while ([xx] seconds), as long as possible. We think conservative setting of NRSRP threshold for each paging carrier group would be already helpful for this purpose. And such [xx] seconds may give a bit more help but the help is limited.  However, after UE fall back to a legacy paging carrier due to deterioration of radio quality, as the eNB still starts trying paging on the selected R17 paging carrier, this will inevitably lead to the failure of the first paging. In such case, we think the most suitable process is to let UE keep the suitability checking before each PO. Once the suitability checking is fulfilled, the UE should return to the assigned coverage level and select a R17 paging carrier as soon as possible. Therefore, it’s better that UE keeps suitability checking after UE fall back to a legacy paging carrier, e.g., no need to apply this [xx] seconds in this case. |
| Qualcomm | Both cases | These are two separate questions.   1. We prefer the UE uses the selected paging carrier for at least a period [x] before it switches to a different paging carrier unless UE changed cell. That is, the hysteresis can be the same whether UE selects legacy paging carrier or coverage-based paging carrier. 2. All POs within the PTW should be monitored on the same paging carrier. |
| Huawei, HiSilicon | Both cases | same views as QC |
| NEC | Both cases | We are fine with avoid paging carrier switching within PTW. |
| Spreadtrum | Both cases | We think a same principle should be kept for monitoring paging in the two cases. |
| Nokia | Both cases | I think specific should say that the carrier which is selected based on coverage level is not changed for given duration irrespective of whether selected carrier is Rel-17 or Rel-16 carrier. |
| Ericsson | Both cases | Agree with Nokia |
| MediaTek | Both cases | As elaborated in R2-2200922, without switching paging carrier delay in both cases can cause losing paging message. |
| Sequans | Both | Agree with QC. The selected carrier should not affect the principle. |

**Summary:**

9 companies provided views to Q2a:

* 8 companies prefer **both cases.** That generally means same hysteresis rules (wait [xx] seconds or avoid paging carrier switching in PTW) would be applied no matter UE selects legacy paging carrier or coverage-based paging carrier. But among the companies, 2 companies (Nokia, Ericsson) only confirm the understanding that the carrier which is selected based on coverage level is not changed for given duration. Rapporteur feel it’s not so clear whether these 2 companies only confirm one case, e.g., **case 1**?
* 1 companies prefer only one case, e.g., **case 1** of after selecting R17 paging carrier, in which hysteresis rules can be applied. For **case 2**, e.g., after fallback to legacy paging carrier, company think UE don’t need to wait [xx] seconds.

Following the majority views, the proposal is given as below:

**Proposal 2a: Same rules, e.g., to wait [xx] seconds or avoid paging carrier switching in PTW would be applied no matter UE selects legacy paging carrier or coverage-based paging carrier.**

**Q2b: Companies are invited to provide comments on how to specify that no paging carrier switching during PTW.**

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| --- | --- |
| **Company** | **Comment** |
| ZTE | We are fine with no paging carrier switching during PTW.  In legacy, UE performs paging carrier selection before each PO. We assume this is also applied to R17 CEL-based paging carrier selection. So we’d better not to touch this part of UE behaviour/process. Maybe a simple way for specifying this intention is to disable/stop suitability checking according to the NRSRP threshold (or just assume the suitability checking is always fulfilled) during PTW. |
| Qualcomm | In general, UE selects the paging carrier before it goes to sleep because UE needs to use the paging carrier specific parameters to determine when the next PO is.  We don’t think it would be too complicated to specify that UE uses the same paging carrier for all POs it monitors during the PTW. |
| Huawei, HiSilicon | We do not think that in legacy the UE performs carrier selection before each PO. There is nothing random about it. UE only needs to do it once when acquiring SIB22 or after S-TMSI reallocation  we also do not think it is difficult to specify that the UE does not switch carrier within a PTW |
| NEC | Agree with ZTE. |
| Spreadtrum | Similar comments as Huawei. Only when the paging carrier related configuration changes in SIB22-NB or S-TMSI reallocation happens, the UE needs to perform carrier selection. Hence, it is simple to specify that the UE does not to perform carrier switching within a PTW. |
| Nokia | We are OK to specify that paging carrier is not changed during PTW. |
| Ericsson | Agree with Huawei. However, if we specify the timer and if timer expires during PTW; UE may switch. That is, we do not need to specify multiple features/behaviour. One timer should be adequate and we do not need to pose further restriction or spec changes etc. |
| MediaTek | According to 24.008 10.5.5.32, the longest PTW length is 40.96 seconds. Although this value is not the typical value, it is still possible to be configured. We should allow paging carrier switch during such a long duration. |
| Sequans | Agree with Ericsson |

**Summary:**

9 companies provided views to **Q2b**:

* 4 companies (Qualcomm, Huawei, Spreadtrum and Nokia) think it can simply specify that UE does not switch paging carrier within a PTW. Among them, 3 companies (Qualcomm, Huawei, Spreadtrum) think in legacy, UE only needs to perform paging carrier selection once when acquiring SIB22 or after S-TMSI reallocation.
* 2 companies (ZTE, NEC) understand that UE performs paging carrier selection before each PO and prefer not to touch this UE behaviour/process. They suggest to disable/stop suitability checking according to the NRSRP threshold (or just assume the suitability checking is always fulfilled) during PTW.
* 2 companies (Ericsson, Sequans) think only one timer is enough. Per rapporteur‘s understanding, they may means only one timer with value of [xx] seconds (this timer is mainly discussed in Q2c). UE is allowed to switch paging carrier if this timer expires. Even UE is in PTW, this rule also applies.
* 1 companies (MediaTek) think we should allow paging carrier switch during PTW as the longest PTW length is 40.96 seconds. Rapporteur tend to think this company have similar view as Ericsson and Sequans.

As this question is related to Q2c, no proposal is given for this Q2b. A merged proposal will be given after Q2c.

**Q2c: Companies are invited to provide comments on how to specify such [xx] seconds, e.g., whether it needs to specify a kind of timer with [xx] seconds? If yes, what’s the conditions for timer start/restart/stop?**

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| **Company** | **Comment** |
| ZTE | We understand [xx] seconds would be mainly applied to the case that eDRX is not configured.  Similar as that for skipping paging carrier switching in PTW, a simple way of implementing this [xx] seconds may be that, after UE selects a R17 paging carrier, UE just stop suitability checking for [xx] seconds. After that, UE can perform suitability checking once, if fulfilled, UE would stay at the current R17 paging carrier and start waiting for another [xx] seconds. |
| Qualcomm | The timer can be in units of DRX cycles.  Start timer: When UE switches between legacy paging carrier and coverage-based paging carrier list.  Timer expiry: UE may change paging carrier list depending on the serving cell condition.  While Timer is running: Re remains on the last selected carrier.  Timer stopped: Upon entry to RRC\_CONNECTED state, and upon cell reselection. |
| Huawei, HiSilicon | we think that [XX] in seconds could be used for all cases that we have for cell reselection, |
| Spreadtrum | We think [xx] seconds could be used regardless whether eDRX is configured. |
| Nokia | For eDRX case restriction at PTW level is sufficient. Timer can be used for DRX configuration. |
| Ericsson | The timer can be periodic; i.e UE remains in a certain carrier for certain duration before switching to another paging carrier for certain duration. The duration on which mode to stay for how long can be controlled using coefficient/offset. |
| MediaTek | Similar view as Qualcomm’s comment.  As the answer for the last question, paging carrier switch should be allowed for eDRX case, therefore, this timer should be applied to eDRX case.  We also suggest the timer in unit of DRX cycles (the actually used one after applying UE specific DRX). And we think one DRX cycle should be enough. |
| Sequans | DRX cycle units make this less arbitrary. We are fine with switch during PTW if the timer is configured. |

**Summary:**

8 companies provided views to Q2c:

* At least 4 companies (Spreadtrum, Ericsson, MediaTek, Sequans) are fine with that this timer can be used for all the cases, regardless of whether eDRX is configured and regardless whether UE is in PTW. Among them, 2 companies suggest the timer in unit of DRX cycles. 1 company think the time duration on which mode to stay for how long can be controlled using coefficient/offset.
* 2 companies (ZTE, Nokia) think for eDRX case, restriction at PTW level is sufficient. Timer can be used for DRX configuration. Among them, 1 company suggest to simply specify that UE just stop suitability checking for [xx] seconds.
* 1 company (Huawei) think that [XX] in seconds could be used for all cases that we have for cell reselection. Rapporteur tend to think this company have similar view as that in the first bullet. But this company is also fine with no switching paging carrier within a PTW in Q2b.
* 1 company (Qualcomm) suggest to specify the start/stop/expiry of the timer. They also suggest the timer in unit of DRX cycles.

With consideration on all the comments and the views that have more support in Q2b and Q2c, the proposal is given as below:

**Proposal 2b: RAN2 discuss and make choice in the following options for reducing paging carrier switching:**

* **Option 1: For the case with eDRX configuration, just to simply specify that UE does not switch paging carrier within a PTW. For the case without eDRX configuration, a timer is specified to reduce paging carrier switching.**
* **Option 2: Only one timer is specified to reduce paging carrier switching in all the cases, e.g., regardless of whether UE is in PTW.**

**Proposal 2c: This timer in Option 1 or Option 2 in Proposal 2b can be started after UE selects legacy paging carrier or coverage-based paging carrier. UE is allowed to switch paging carrier if timer expires.**

**Q2d: Companies are invited to provide comments on what’s the suggested value of [xx], xx seconds or value in units of DRX/eDRX cycle? Is it configurable or hard-coded?**

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| **Company** | **Comment** |
| ZTE | For simplicity, we think such [xx] seconds can be hard-coded, e.g., 20.48 seconds or 2 maximum DRX cycles.  Configurable way is also acceptable to us. |
| Qualcomm | The minimum period [xx] for which UE remains on one paging carrier should be configurable and in units of DRX cycle e.g., 1, 2, 4, 8. |
| Huawei, HiSilicon | we propose to have the value configurable in sec |
| Spreadtrum | We think both xx seconds and value in unit of DRX/eDRX cycle are acceptable. It is just a matter of expression form. |
| Nokia | Agree with Huawei. The timer value can be defined in seconds |
| Ericsson | Wse also think timer in seconds is right choice. The timer can be periodic as such.  UE can first start Coverage level paging monitoring for a during of *periodicTimer* on certain Rel-17 paging carriers. When *periodicTimer* expires, UE will start legacy (Rel-16) paging carrier monitoring for a during of *coeff \* periodicTimer*. The configuration parameter *periodicTimer* and *coeff* can be set considering UE’s foreseen possibility of Coverage level changes. |
| MediaTek | A hardcoded value of one DRX cycle (the actually used one after applying UE specific DRX) |
| Sequans | Configurable value. In DRX cycles would be best, but we are fine with seconds as well. |

**Summary:**

8 companies provided views to Q2d:

* 3 companies (Huawei, Nokia, Ericsson) prefer the unit for the timer is seconds.
* 3 companies (Qualcomm, Sequans, MediaTek) prefer the timer unit is DRX cycles. Among them, 2 companies think it can be configurable, e.g., with 1, 2, 4, 8. 1 company prefer a hardcoded value of one DRX cycle.
* 3 companies (ZTE, Spreadtrum, Sequans) are fine with either way.
* 2 companies (ZTE, MediaTek) mentions the hardcoded way for the timer.

Rapporteur feel more companies suggest the length of this timer is configurable.

As the other views are diverse, the proposal is given as below:

**Proposal 2d: The length of the timer in Option 1 or Option 2 in Proposal 2a is configurable. RAN2 further discuss what’s the unit of the timer: DRX cycle or seconds?**

**Q2e: Any other issues for such [xx] seconds?**

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| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Consider the case UE enters RRC\_IDLE from RRC\_CONNECTD and dedicated signalling provided coverage-based paging carrier index. In this case should UE select paging carrier according to the carrier index or should UE remain on the same paging carrier as it was using before in entered RRC\_CONNECTED state at least for a period [xx].  This is why we think just because the UE sent serving cell measurement report is not sufficient to use the coverage-based paging carrier. |
| Huawei, HiSilicon | We think that UE after being released can assume a priori the assigned coverage level. |
| **Ericsson** | Agree with Huawei. If UE has been provided with Rmax value; UE selects a carrier and monitors paging in that 1st. That is the timer should be released when UE transits to connected mode. |
| Sequans | We are fine with the assigned coverage level. Whether it should be assigned at all is a different issue, see next open issue. |

**Summary:**

1 company ask when UE enters RRC\_IDLE, should UE select paging carrier according to the carrier index or should UE remain on the same paging carrier as it was using before in entered RRC\_CONNECTED state at least for a period [xx]? The other 3 companies give similar response that they think the assigned coverage level should be prioritized and UE should follow this.

Rapporteur understand the response of the 3 companies is aligned with the existing agreements for CEL-based paging carrier selection. So no new issue is identified and no new proposal.

## Open Issue 3: UE report

RAN2 has agreed that *UE measured NRSRP can be reported for assisting the network to provide suitable coverage level related information.* It’s still FFS on the detailed report way.

During “*[AT116bis-e][301][NBIOT/eMTC R17] Carrier Selection* (R2-2201786)” email discussion, more companies (6/9) prefer the simple way, e.g., the **Option 1**. At the same time, some other companies think this is not enough and prefer **Option 2** below:

* **Option 1:** to make legacy Msg5 report mandatory.
* **Option 2:** to report an indication on whether the existing CQI report is suitable for coverage-based paging carrier selection.

**Q3: Companies are invited to provide your preference on the above options for the UE report and please elaborate the reasons.**

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| --- | --- | --- |
| **Company** | **Option** | **Comment** |
| ZTE | Option 1 | We think Option 1 is clear and enough.  We are not clear about the details of the Option 2, e.g., is it a simple indication (e.g., “Yes” for suitable and “No” for unsuitable) or some other mapping format? When to send such indication? Also, in Msg5 or during the connection?  Proponent company of Option 2 is invited to provide more details of the usage and details (e.g., when to report and what’s the report format) of Option 2**.** |
| Qualcomm | Option 2 | We think for reliable operation of this feature either make the serving cell measurement reporting conditional on the UE having been on a paging carrier at least for a period [xx], or add an indication that indicates the UE has been on the current paging carrier at least for a period [xx] hence it is reliable enough for network to use this for coverage-based paging carrier group selection. |
| Huawei, HiSilicon | Not option 2. | Option 1 is not absolutely necessary. eNB can ask the UE to report the CQI during the connection.  If the UE cannot provide any of them then the eNB eventually does not assign a coverage level |
| Spreadtrum | Option 1 | We also think option 1 is clear and definite. For option 2, more details should be further taken into consideration. |
| Nokia | Option1 not needed | As per current specification CEL is already informed to CN as part of RRC connection release. Network can provide the PCG based on the same estimation used for this CEL towards UE. Additional UE assistance information is not necessary. If the UE is in RRC connection for longer timer, the latest CQI only needs to be referred. In this case Msg5 report is not used. |
| Ericsson | Option 1 | We agree Option 1 does not have to be mandatory, but it can be changed to conditional for Rel-17 UEs which supports Rel-17 paging carrier selection. We agree with Nokia that NW may have some info but it is also good to get one more measurement report from UE for reliable decision. |
| MediaTek | Option 1 | Option 1 is simple and straight forward. |
| Sequans | Option 2 | Msg5 report does not have to be mandatory. However, when the report is provided is irrelevant. We have agreed “*A configurable cell specific timer period can be applied when UE compares its serving cell NRSRP with the NRSRP threshold*”; therefore, if the NW wants to base (completely or partly) its carrier decision on UE report, it should be aware whether the measurement would have actually satisfied the UE for this purpose, otherwise it should not be part of the NW considerations. |

**Summary:**

8 companies provided views to Q3:

* 4 companies (ZTE, Spreadtrum, Ericsson, MediaTek) prefer Option 1 for UE report. Among them, 1 company think it can be conditionally mandatory for R17 UE supports Rel-17 paging carrier selection.
* 2 companies (Qualcomm, Sequans) prefer Option 2 for UE report.
* 2 companies (Huawei, Nokia) think additional UE assistance information is not necessary. NW may have some other info and the latest CQI only needs to be referred (note that in legacy, eNB can determine a CEL and send it to core network). Or if the UE cannot provide any information, the eNB eventually does not assign a coverage level. Among them. 1 companies against Option 2.

As this issue has been discussed several meetings, more companies think such UE report is useful but not so critical. Rapporteur think we’d better not to spend too much time on this. So following a bit more companies’ views, the proposal is given as below:

**Proposal 3: CQI report in Msg5 is conditionally mandatory for R17 UE that supports Rel-17 paging carrier selection. No other UE report is supported.**

## Open Issue 4: ASN.1 structure for paging carrier configuration in SIB

RAN2 has agreed most needed IEs for the R17 paging carrier list configuration in SIB. But how to organize the Ies in ASN.1 are still FFS.

More details can be left to TS 36.331 running CR discussion, but before that, as rapporteur, we want to suggest that companies can firstly decide the high level direction, e.g., make choice between the below **Approach 1** and **Approach 2**. Please note the details of **Approach 1** and **Approach 2** have already been described in the on-going TS 36.331 running CR (“*[Post116bis-e][316]*”):

* **Approach 1:** just to extend *PCCH-ConfigList-NB*
* **Approach 2:** to introduce a new R17 paging carrier list

**Q4: Companies are invited to provide your preference on the above approach for ASN.1 structure for paging carrier configuration in SIB and please elaborate the reasons for your choice.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Approach** | **Comment** |
| ZTE | Approach 1 | As background, in legacy, a DL non-anchor carrier can be used as paging carrier or RAR carrier. The configuration for paging carrier (with ***pcch-Config***) or RAR carrier (with the npdcch related configuration in ***NPRACH-Parameters-NB***) are separated. For example, the RAR carrier configuration is as below:  NPRACH-Parameters-NB-r14 ::= SEQUENCE {  nprach-Parameters-r14 SEQUENCE {  nprach-Periodicity-r14 ENUMERATED {ms40, ms80, ms160,  ms240, ms320, ms640, ms1280, ms2560} OPTIONAL, -- NEED OP  //skip//    npdcch-NumRepetitions-RA-r14 ENUMERATED {r1, r2, r4, r8, r16, r32, r64, r128, r256, r512, r1024, r2048, spare4, spare3, spare2, spare1} OPTIONAL, -- NEED OP  npdcch-StartSF-CSS-RA-r14 ENUMERATED {v1dot5, v2, v4, v8, v16, v32, v48, v64} OPTIONAL, -- NEED OP  npdcch-Offset-RA-r14 ENUMERATED {zero, oneEighth, oneFourth, threeEighth}OPTIONAL, -- NEED OP  //skip//  npdcch-CarrierIndex-r14 INTEGER (1..maxNonAnchorCarriers-NB-r14) OPTIONAL, -- Need OP  ...  } OPTIONAL -- Need OR  }   |  | | --- | | ***npdcch-CarrierIndex***  For FDD: Index of the carrier in the list of DL non anchor carriers. The first entry in the list has index ‘1’, the second entry has index ‘2’ and so on.  If the UE supports mixed operation mode and *dl-ConfigListMixed* is present in *systemInformationBlockType22-NB*, the UE creates a combined list of DL carriers for random access by appending *dl-ConfigListMixed* to the *dl-ConfigList* while maintaining the order among both *dl-ConfigList* and *dl-ConfigListMixed*; only the first *maxNonAnchorCarriers-NB-r14* DL non-anchor carriers in the concatenated list can be used for random access.  If the field is absent in the entry in *nprach-ParametersListEDT* in *SystemInformationBlockType22-NB*, the value of *npdcch-CarrierIndex* in the corresponding entry of *nprach-ParametersList* applies, if present. If the field is absent in an entry in *nprach-ParametersListFmt2EDT* in *SystemInformationBlockType23-NB*, the value of *npdcch-CarrierIndex* in the corresponding entry of *nprach-ParametersListFmt2* applies, if present. Otherwise, the DL anchor carrier is used.  For TDD: This parameter is absent and the same carrier is used in uplink and downlink. | | ***Npdcch-NumRepetitions-RA***  Maximum number of repetitions for NPDCCH common search space (CSS) for RAR, Msg3 retransmission and Msg4, see TS 36.213 [23], clause 16.6.  See NOTE. | | ***Npdcch-Offset-RA***  Fractional period offset of starting subframe for NPDCCH common search space (CSS Type 2), see TS 36.213 [23], clause 16.6.  See NOTE. |   If we introduce a new R17 paging carrier list as that *cbpcg-PCCH-ConfigList-r17* and *cbpcg-PCCH-ConfigMixedList-r17* in **Approach 2** in TS 36.331 running CR, we think we need to clarify whether “the list of DL non anchor carriers” in the definition of ***npdcch-CarrierIndex*** can include the new R17 DL paging carrier list? Per our understanding for the current **Approach 2**, it seems a pure paging carrier list would be introduced, that cannot be used for RAR. We think this is undesired and not aligned with the legacy rule for non-anchor carrier configuration.  Conversely, the main rule of **Approach 1** is that a DL non-anchor carrier can be configured with R14 paging resources or R17 paging resources. With this way, we can try to make the R17 paging carrier configuration has as little impact on the existing non-anchor carrier configuration as possible. Moreover, in our assumption, the legacy UE is still allowed to use the carriers in R17 paging carrier list as the RAR carriers. Meanwhile, the R17 UE is also allowed to use the carriers in the legacy paging carrier list as the RAR carriers. This is feasible with **Approach 1.**  Therefore, we prefer **Approach 1.** We have some clarifications for **Approach 1**, those are not discussed here and will be provided in 36.331 running CR review. |
| Qualcomm | Approach 2 preferred | In principle both options can technically work.  Conceptually Approach 2 is easier for the reader to understand. Note, when (G)WUS was introduced it made sense to just extend pcch-Config-r14 because (G)WUS was an additional parameter, it did not replace the existing parameters. With coverage-based paging carriers, not only there are more parameters to configure but the parameter values are expected to be different from those configured in pcch-Config-r14.  ASN.1 corresponding to the current agreements is provided in the running CR for both approaches. We think it is much easier to discuss this aspect as part of the running CR because reader can see how two options look. |
| Huawei, HiSilicon | Approach 1 preferred | We think that both approaches work an , based on the draft running CR, we think there is little difference between the two options both in terms of signalling overhead and complexity. In approach 1, we need to link the carrier to a paging carrier group index. In approach 2, we need to link the paging carrier group to a paging carrier index.  Now, conceptually, we have a preference for option 1 as it aligns with the legacy approach to have a list of DL carriers and their associated functionalities. With approach 2, we have an orthogonal approach. i.e. a functionality with the associated carriers |
| Spreadtrum | Approach 1 preferred | The legacy structure is enough to place the new configuration, and, the unified structure is easier for read and understanding. |
| Nokia | Approach 1 |  |
| Ericsson | Approach 1 | We would also prefer to have a more legacy approach |
| MediaTek | Approach 2 | Approach 1 is to extend PCCH config for the non-anchor DL carrier list, which allows legacy UEs who do not recognize the Rel-17 PCCH config IE to select Rel-17 coverage based carrier and try to receive paging message.  However, RAN2 has agreed that “Rel-17 paging carriers and the legacy paging carriers should be exclusive.” in RAN2#114-e. The approach 1 directly contradict this agreement. |
| Sequans | Approach 1 preferred | Agree with HW |

**Summary:**

8 companies provided views to Q4 about ASN.1 structure for paging carrier configuration in SIB:

* 6 companies prefer Approach 1.
* 2 companies prefer Approach 2. Among them, 1 company think the Approach 1 directly contradict this agreement “*Rel-17 paging carriers and the legacy paging carriers should be exclusive*”. But per rapporteur’s understanding, the intention of both Approach 1 and Approach 2 is to achieve exclusive configuration for R17 paging carrier list with minimum ASN.1 signalling impacts. Maybe the more suitable wording for Approach 2 is that to introduce a new IE for R17 paging carrier list.

The proposal is given as below to reflect the majority views. But it’s also fine to have no related agreement. The TS 36.331 rapporteur can just take into account the companies’ preference when they prepare the TS 36.331 running CR. And companies can give detailed suggestion during 36.331 running CR review:

**Proposal 4: RAN2 use the way of extending *PCCH-ConfigList-NB* to provide the R17 paging carrier list configuration in SIB.**

## Open Issue 5: RAN3 impacts

In the previous meeting discussion and in the contributions, it has been mentioned that the assigned information to UE in dedicated signaling, e.g., the paging carrier group index, may also need to be delivered to core network and further sent back to eNB in next time paging.

**Q5a: Companies are invited to provide your comments on whether the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| ZTE | Yes | We think the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging.  The purpose is to make target eNB aware that the related UE is using CEL-based paging carrier selection scheme and make the target gNB exactly know the coverage level that the UE is using. Then the target eNB can apply the same R17 paging carrier selection scheme to send paging in air interface. |
| Qualcomm | Yes | It absolutely necessary for network to remember the coverage-based paging carrier index signalled to the UE. Otherwise the feature would not work reliably. |
| Huawei, HiSilicon | Yes |  |
| Spreadtrum | Yes | At least the determined information of CE level should be sent back to eNB in the next paging. |
| Nokia | Yes | Either CEL or the PCG assigned to the UE should be indicated to CN. Sending CEL may lead to issues if the CEL of PCG (paging carrier group) is changed later via system information before paging. In this case RAN may need to select group closer to the CEL received from CN. |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| Sequans | Yes |  |

**Summary:**

8 companies provided views to Q5a. All the companies can agree with the understanding that the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging.

Following the majority views, the proposal is given as below:

**Proposal 5a: It’s RAN2 assumption that the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging.**

Per rapporteur’s knowledge, RAN3 has had some related discussion but no agreement can be achieved. It seems the following options have been discussed in RAN3, for delivering the assigned information to UE in dedicated signaling to core network and sent back to eNB:

* **Option 1:** in *UEPagingCoverageInformation* RRC container. This means RAN2 change.
* **Option 2:** in S1/NG signaling, e.g., in *Cell Identifier and Coverage Enhancement Level* IE in TS 36.413 and in *Paging Assistance Data for CE Capable UE* IE in TS 38.413. This means RAN3 change.

**Q5b: If the answer to Q5a is yes, companies are invited to provide your preference on the following Options:**

* **Option 1:**
* **Option 2**
* **Other option**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| ZTE | Option 2 | We think explicit inclusion of the assigned information to UE in RAN3 signaling (**Option 2**) would be clearer.  If we go for **Option1**, it may need to explicitly describe that the paging carrier group index can only be included in the *UEPagingCoverageInformation* only if it is provided to the UE in the release message.  No matter we go for **Option 1** or **Option 2**, we think we’d better to send LS to RAN3 as soon as possible to let them know our choice. |
| Qualcomm | Option 1 | The coverage-based paging carrier group index is only used by the cell that signalled it to the UE. When paging the UE not only this index but also the coverage-information useful.  It is true the current SA2 specific (wrongly in our view) prevents the CN from providing coverage information for UE with restricted-coverage but there are no such restrictions in RAN2 or RAN3 specifications.  In our view option 2 is not justified.  As RAN3 has sent an LS to RAN2, RAN2 should provide response even if there is no impact to RAN3 specification. |
| Huawei, HiSilicon | Option1 | Option 1 seems the quite obvious solution from RAN2 point of view. We agree with QC that the current restriction in SA2 is not correct but even if it was, it is not needed.  We also agree that we need to reply to RAN3 LS whatever RAN2 decision. |
| Spreadtrum | Option 2 | Agree with ZTE. It is clear and straightforward to convey it in RAN3 signalling. |
| Nokia | Option 1 | Changes can be restricted within RAN2. |
| Ericsson | Option 1 |  |
| Sequans | Option 1 |  |

**Summary:**

7 companies provided views to Q5b about how to deliver the assigned information to UE in dedicated signaling to core network and sent back to eNB:

* 5 companies prefer to use *UEPagingCoverageInformation* as they prefer to restrict the changes within RAN2.
* 2 companies prefer to explicitly define new IE in RAN3 signaling.

Following the majority views, the proposal is given as below. The opposing companies can raise specific issues during online discussion if they find one or some:

**Proposal 5b: *UEPagingCoverageInformation* RRC container is used to deliver the assigned information to UE in dedicated signaling to core network and sent back to eNB. A response LS to RAN3 would be sent as early as possible.**

## Other issue

**Q6: Companies are invited to indicate whether there is any other issue for CEL-based paging carrier selection?**

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |
| Qualcomm | Combination of the following two agreement seems to cause confusion:   * In SIB, coverage specific nB is supported, e.g., a common nB value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging). * Rmax may be configured per carrier or per carrier group (coverage level).   It is clear all coverage-based paging carriers for one coverage level can have same or different Rmax values. But this also implies nB can also be same or different for all coverage-based paging carriers for one coverage level. **It would be good to confirm that nB can be different for each coverage-based paging carriers for one coverage level.** |
| Huawei, HiSilicon | We agree that we need to reconfirm the agreement but in our view it is fine to have it per paging carrier group, same a UE-specific-DRX-min. Note that nB is not so much related to Rmax but mostly to the DRX cycle. |
| Nokia | NB can be common for paging carrier group. Very big variation in Rmax only impacts NB and which also impacts DRX cycle. The Rmax within paging carrier group may differ in Rmax just for coverage difference due to different frequency/band. This will not have impact to NB. |

**Summary:**

In previous meeting, RAN2 has agreement that “*In SIB, coverage specific nB is supported, e.g., a common nB value is configured for the R17 paging carrier(s) with same Rmax (npdcch-NumRepetitionPaging)*”. As we have another agreement that “*Rmax may be configured per carrier or per carrier group (coverage level)”*, 1 company suggest to confirm that nB can also be different for each coverage-based paging carriers for one coverage level. The other 2 companies give similar response that nB can be common for paging carrier group as nB is not so much related to Rmax.

Rapporteur understand more companies think the main part of the previous agreement, e.g., “*coverage specific nB is supported*” has no issue. Rapporteur think the remaining description related Rmax can be seen as example. It may be considered to remove this part if companies think it’s really needed. So no new issue is identified and no new proposal.

# Conclusion

Proposals for easy agreement:

**Proposal 1: RAN2 introduces a new *ue-SpecificDRX-CycleMin* parameter which is configured per coverage level.**

**Proposal 2a: Same rules, e.g., to wait [xx] seconds or avoid paging carrier switching in PTW would be applied no matter UE selects legacy paging carrier or coverage-based paging carrier.**

**Proposal 3: CQI report in Msg5 is conditionally mandatory for R17 UE that supports Rel-17 paging carrier selection. No other UE report is supported.**

**Proposal 4: RAN2 use the way of extending *PCCH-ConfigList-NB* to provide the R17 paging carrier list configuration in SIB.**

**Proposal 5a: It’s RAN2 assumption that the assigned information to UE in dedicated signaling also need to be delivered to core network and sent back to eNB in next paging.**

**Proposal 5b: *UEPagingCoverageInformation* RRC container is used to deliver the assigned information to UE in dedicated signaling to core network and sent back to eNB. A response LS to RAN3 would be sent as early as possible.**

Proposal for further discussion:

**Proposal 2b: RAN2 discuss and make choice in the following options for reducing paging carrier switching:**

* **Option 1: For the case with eDRX configuration, just to simply specify that UE does not switch paging carrier within a PTW. For the case without eDRX configuration, a timer is specified to reduce paging carrier switching.**
* **Option 2: Only one timer is specified to reduce paging carrier switching in all the cases, e.g., regardless of whether UE is in PTW.**

**Proposal 2c: This timer in Option 1 or Option 2 in Proposal 2b can be started after UE selects legacy paging carrier or coverage-based paging carrier. UE is allowed to switch paging carrier if timer expires.**

**Proposal 2d: The length of the timer in Option 1 or Option 2 in Proposal 2b is configurable. RAN2 further discuss what’s the unit of the timer: DRX cycle or seconds?**

# References

[1] R2-2200030, Report of [Post116-e][311] NB-IoT carrier selection (ZTE), RAN2#116bise

[2] R2-2201786, Report of [AT116bis-e][301][NBIOT/eMTC R17] Carrier Selection (ZTE), RAN2#116bise

[3] R2-2201795, Report of [310] Carrier selection open issues (ZTE), RAN2#116bise