3GPP TSG-RAN WG2 #115e R2-21xxxxx

Electronic meeting, August 16th – May 27th, 2021

Agenda Item: 9.1.3

Source: Ericsson

Title: [Pre115-e][302][NBIOT/eMTC R17] Summary of AI 9.1.3 NB-IoT carrier selection

Document for: Discussion, Decision

# 1 Introduction

The below papers were submitted in the AI 9.1.3 and part of the discussion.

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| [1] | [R2-2107812](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107812.zip) | Further analysis on solution for coverage level based paging carrier selection | Nokia, Nokia Shanghai Bell |
| [2] | [R2-2107762](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107762.zip) |

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| Remaining issues on CEL-based paging carrier selection |  |

 | ZTE Corporation, Sanechips |
| [3] | [R2-2107123](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107123.zip) | Support for NB-IoT carrier selection based on the coverage level | Qualcomm Incorporated |
| [4] | [R2-2107124](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107124.zip) | Signalling for coverage-based paging carrier selection | Qualcomm Incorporated |
| [5] | [R2-2107207](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107207.zip) | Discussion on details of paging carrier selection options | MediaTek Inc. |
| [6] | [R2-2107430](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107430.zip) | Paging carrier selection | Huawei, HiSilicon |
| [7] | [R2-2107391](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107391.zip) | Further discussion on enhanced paging carrier selection | NEC Corporation |
| [8] | [R2-2107370](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2107370.zip) | Further discussion on enhanced paging carrier selection | Spreadtrum Communications |
| [9] | [R2-2108391](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_115-e/Docs/R2-2108391.zip) | Paging Carrier Selection | Ericsson |

9 papers have been submitted in this area. In order to have meaningful discussion and to get the most from the online session, it is suggested to list the comparisons on different aspects for the following two options:

* Option 1: UE selects a paging carrier based on a rule configured by the network
* Option 2: NW configures a specific paging carrier

# 2 Discussion

## 2.1 DRX support for carrier selection criteria

Except the paging carrier selection based on coverage level, RAN 2#114-e further discussed if DRX should be considered. For option 2, companies agreed that it is natural to consider DRX, while for option 1, an FFS is reached:

* FFS: For option 1, whether DRX can be part of the carrier selection criteria

The following proposals regarding whether DRX can be part of the carrier selection criteria are provided:

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| Tdoc | Proposals |
| [1] | **Proposal 8: Carrier selection based on combination of DRX and coverage level is not supported.****Proposal 9: RAN2 can consider DRX based carrier selection when coverage based paging carrier selection is not configured.** |
| [2] | **Proposal 2a: The carrier-specific DRX cycle configuration can be supported for Option 1.****Proposal 2b: Paging carrier selection based on carrier-specific DRX cycle can be used on top of the results from CEL-based paging carrier selection*.*** |
| [5] | **Proposal 1: support DRX based paging carrier selection for option 1.** |
| [6] | **Proposal** **4**: For option 1, the paging carrier DRX cycle is not used in the paging carrier selection criteria. |
| [8] | **Proposal 1：The DRX should be part of the carrier selection criteria.****Proposal 2: Combine DRX cycle with CE level for carrier selection criteria.** |
| [9] | **Proposal 2: Solution supporting DRX is given weightage while doing down-selection between two Options.** |

The proposals can be categories as follows for option 1:

a) DRX should be part of paging carrier selection criteria [1][2][5][8][9], where two different alternatives are mentioned:

Alt 1: Support DRX based carrier selection when coverage based paging carrier selection is not configured [1]

Alt 2: Combine DRX cycle with CE level for carrier selection criteria [2][8]

b) DRX is not used in the paging carrier selection criteria [6]

Based on the majority view, the following is proposed:

Proposal For option1, DRX should be part of the carrier selection criteria. RAN2 to discuss how to combine the DRX criteria with CE level criteria.

## 2.2 DRX parameter configuration

Regarding DRX parameter configuration, the following proposals are provided:

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| Tdoc | Proposals |
| [2] | **Proposal 8b: It should be allowed that the paging related parameters, e.g., the *npdcch-NumRepetitionPaging, defaultPagingCycle and* nB can be configured for the carrier(s) for a certain CEL. The *npdcch-NumRepetitionPaging* and *nB* needs to be same for all the carriers for a certain CEL.**  |
| [4] | If paging carrier specific DRX is agreed to be supported. The signalling proposed in Table 2 assumes carrier specific DRX support with all value range as in Release 16.**Proposal 3: nB is optionally configured for each coverage based paging carrier.** |
| [5] | **Proposal 1a: a minimum value of UE specific DRX cycle per carrier should be introduced for non-anchor carriers in system information for both options.****Proposal 2:to support an nB configuration per carrier for both options.** |
| [6] | **Proposal 1**: For both options, Rel-17 paging carriers can be configured with a shorter paging cycle than the default cell paging cycle.**Proposal** **2**: For both options, Rel-17 paging carriers can be configured with a larger nB than the default cell nB.**Proposal** **3**: For both options, Rel-17 paging carriers can be configured with a smaller *ue-SpecificDRX-CycleMin* than the default cell *ue-SpecificDRX-CycleMin*. |
| [7] | **nB**nB used to be cell specific and reflects the density of paging occasions within one default paging cycle. The configuration of nB needs to guarantee that CSS overlapping for paging is avoided. From this point of view, if carrier specific Rmax is allowed, carrier specific nB could be considered.**ue-SpecificDRX-CycleMin**In Rel-16, minimum UE specific DRX cycle was introduced to ensures PCCH configuration does not lead to CSS overlap. From this point of view, if it is allowed to support different coverage on different carriers, expanding this parameter from cell specific to carrier specific could also be considered to avoid CSS overlapping on each carrier.Proposal 2: RAN2 discuss the details of the parameters provided in broadcast information.  |

For the DRX parameter configuration, including *defaultPagingCycle*, *nB,* and *ue-SpecificDRX-CycleMin*, the proposals by companies above can be summarized as:

*defaultPagingCycle* can be optional configured as carrier specific [2][4][6].

*nB* can be optional configured as carrier specific [4][5][6][7] or CEL specific [2]

*ue-SpecificDRX-CycleMin* can be optional configured as carrier specific [5][6][7].

Based on the majority view, the following is proposed:

Proposal Support carrier specific DRX configurations, including carrier specific *defaultPagingCycle*, *nB,* and *ue-SpecificDRX-CycleMin*.

## 2.3 Paging carrier selection upon cell change

In RAN2#114-e, regarding cell change, the following agreements are achieved. A consensus is reached for option 2, while for option 1, there is an FFS left:

* For option 1, upon cell change, FFS:
* Alt 1: based on previously determined CEL and broadcasted paging carrier configuration in the new cell.
* Alt 2: UE needs to perform fallback mechanism.

The following proposals regarding paging carrier selection upon cell change are provided:

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| Tdoc | Proposals |
| [1] | **Proposal 5: UE selection Rel-17 paging carrier based on RSRP threshold broadcasted for Rel-17 carriers after cell reselection is supported.** **Proposal 6: Network control for coverage-based carrier selection after cell reselection via dedicated signalling is supported.** |
| [2] | **Proposal 1: Upon cell change, as long as R17 coverage based carrier selection criteria is met, Option 1c can be used continuously based on previously determined CEL and broadcasted paging carrier configuration in the new cell.** |
| [3] | **Proposal 2:** **Upon coverage level degradation or upon cell reselection use fallback mechanism (i.e., use legacy scheme for paging carrier selection).****Proposal 3:** **Upon return to cell for which UE specific paging carrier is configured without perform dedicated signaling in other cells the UE may continue to use UE specific paging carrier if coverage level is suitable to use UE specific paging carrier.** |
| [5] | **Proposal 3: to allow paging carrier selection based on previously determined CEL after a cell change for option 1.****Proposal 3a: to allow only the UE with the best CE level before and after cell change can select the paging carrier.****Proposal 3b:** **a new parameter in SI to allow to select paging carrier after a cell change.** |
| [6] | **Proposal** **9**: For option 1, the UE falls back to the legacy carrier upon cell change. |
| [7] | Proposal 3: UE needs to perform fallback mechanism upon cell change |
| [8] | **Proposal 4: Upon cell change, UE selects a paging carrier based on previously determined CEL and broadcasted paging carrier configuration in the new cell.**  |
| [9] | **Proposal 9 For option 1, upon cell change, Alt 2 should be adopted: UE needs to perform fallback mechanism.** |

For option 1, upon cell change, companies still have different views:

Alt 1: based on previously determined CEL and broadcasted paging carrier configuration in the new cell [1][2][5][8].

Alt 2: UE needs to perform fallback mechanism [3][6][7][9].

Proposal For option 1, upon cell change, FFS is needed to choose from Alt 1 and Alt 2.

## 2.4 UE metric for determining carrier suitability

In RAN2#114-e, regarding the question “How does UE select carrier, based on what criteria and metrics?”, the agreement below is reached on UE metric to determine carrier suitability and to select paging carrier:

* Working assumption: UE metric for determining carrier suitability and selection is based on measured NRSRP. FFS whether to use a hysteresis/longer averaging/timer

The following proposals regarding UE metric for determining carrier suitability are provided:

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| Tdoc | Proposals |
| [1] | As the main intention of coverage level based carrier selection is have separate paging carriers for UE in normal coverage to minimize the impact of configuration with higher R-MAX value, the accuracy of measurements in normal coverage will be good enough to ensure the same paging carrier selection at UE and Network. Hence we don’t see further changes to consider hysteresis or multiple measurements in this scenario.**Proposal 7: RAN2 to Confirm the Working assumption: UE metric for determining carrier suitability and selection is based on measured NRSRP as agreement.** |
| [2] | As anyway eNB can handle the case that UE fallback when it finds unsuitability of the determined carrier, e.g., also to fallback after first time paging failure or paging on both determined carrier and fallback carrier, we don’t see the clear need to define the metrics for UE to determine carrier suitability. This can be left to UE implementation.**Proposal 4: How to decide the suitability of the determined paging carrier can be left to UE implementation** |
| [3] | **Proposal 1: Use long term UE specific paging NPDCCH decode metrics to determine optimal Rmax.****Proposal 4: UE metrics should be gathered over a period of at least 24-hours for the paging carrier selected according to legacy scheme.** **Proposal 5: The UE metrics for each paging occasion should be NRSRP and NPDCCH repetitions.****Proposal 6: From the gathered metrics, UE then determines the minimum number of repetitions required to decode at least 90% of the paging occasions.**  |
| [5] | **Proposal 5: For both options, an averaging of metrics can be left to UE implementation.** |
| [6] | In the last RAN2 meeting, it was agreed that NRSRP will be the metric used for paging carrier selection. It was also discussed that using an ‘instantaneous’ value could lead to ping pong between paging carriers and that a ‘long term’ value should be used instead.**Proposal** **7**: For both options, the UE does not switch paging carrier if it has stayed less that [xx] seconds or the duration of the PTW if longer on the current paging carrier.**Proposal** **8**: For both options, 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. |
| [8] | **Proposal 3: The CE level can be determined by the configured thresholds and the transient measured NRSRP.**  |
| [9] | **Proposal 3 Confirm the WA: UE metric for determining carrier suitability and selection is based on measured NRSRP.** **Proposal 4 No need to introduce NRSRP longer averaging/timer.** **Proposal 5 Introduce RRC configurable NRSRP hysteresis to avoid ping-pong.** |

Regarding UE metric for determining carrier suitability and whether to use a hysteresis/longer averaging/timer, companies still have divergent views.

For UE metric for determining carrier suitability and selection, the proposals above can be summarized as:

a) UE metric for determining carrier suitability and selection is based on measured NRSRP [1][6][8][9]

b) UE metric for determining carrier suitability and selection is based on NRSRP and NPDCCH repetitions [3]

c) UE metric for determining carrier suitability and selection is left to UE implementation [2]

Based on the majority view, the following is proposed:

Proposal Confirm the WA: UE metric for determining carrier suitability and selection is based on measured NRSRP.

Regarding FFS whether to use a hysteresis/longer averaging/timer, the proposals above can be summarized as:

a) No need to consider using long term metric [1][8]

b) No need to consider long term metric, but can introduce NRSRP hysteresis [9]

c) Long term UE metric should be used over a period of at least 24-hours [3]

d) Long term UE metric should be used over a period of 5 mn or one eDRX cycle if longer[6]

e) it should be left to UE implementation [2] [5]

As there is no consensus on this issue, propose to have further discussion:

Proposal FFS whether to use a hysteresis/longer averaging/timer for UE metric based on NRSRP.

## 2.5 UE report

In RAN2#114-e, there were proposals on UE report to help the network in the configuration of the selection criteria (option 1) or the selection of a paging carrier (option 2).

* Option 1c: Network enables UE to select a Rel-17 paging carrier by providing the coverage information (CEL/Rmax) for the carrier selection to the UE in dedicated signalling
* Option 2a: NW indicates the carrier to use explicitly via dedicated signalling based on information determined within the NW.
	+ FFS for both options whether there is a report from the UE to suggest a carrier or provide a metric report

The following proposals regarding UE report are provided:

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| --- | --- |
| Tdoc | Proposals |
| [2] | **Proposal 3: It’s no need to introduce UE assistance information/preference report for R17 paging carrier selection scheme.** |
| [3] | For option 1 (i.e., UE selects one paging carrier from the configured coverage-based paging carriers) UE then selects a paging carrier in this cell that has the lowest Rmax but the Rmax is equal to or higher than the minimum repetitions determined by the UE.For option 2 (i.e., network decides what paging carrier to configure), UE reports to the network the minimum number of repetitions required when using legacy carrier and network then use this information to determine the suitable UE specific paging carrier to configure to this UE in this cell. |
| [5] | **Proposal 4: For both options, no need to introduce a UE report of suggestion a carrier or providing a metric.** |
| [6] | **Proposal** **5**: For both options, there is no need to introduce new UE reporting to assist in the configuration of the paging carrier selection criteria / selection of the paging carrier.**Proposal** **6**: RAN2 to discuss whether support of idle mode cell measurement reporting and/or support of the downlink channel quality report in connected mode are prerequisites for coverage based paging carrier. |
| [9] | **Proposal 8 For both options, UE report can be supported only if it is optional and not frequent.** |

[2][5][6] propose that there is no need to introduce UE report, [3] mentions UE reports to the network of the minimum number of repetitions required when using legacy carrier, while [9] propose to use UE report only if it optional and not frequent.

Based on the majority view, the following is proposed:

Proposal For both options, there is no need to introduce UE report.

## 2.6 UE capability

Regarding UE capability for paging carrier selection, the following proposals are provided:

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| Tdoc | Proposals |
| [1] | The UE capability of paging carrier selection based on coverage level and network configuration is also informed to MME as part of radio paging capability. This information is also sent from MME to RAN when S1 Paging message is sent.  |
| [5] | **Proposal 6: For both options, a UE capability parameter of paging carrier selection should be specified.** |

Based on the proposals above, the following is proposed:

Proposal UE capability for Rel-17 paging carrier selection should be introduced.

## 2.7 Paging carrier option comparison

Regarding the two options for paging carrier selection,

* Option 1c: Network enables UE to select a Rel-17 paging carrier by providing the coverage information (CEL/Rmax) for the carrier selection to the UE in dedicated signalling
* Option 2a: NW indicates the carrier to use explicitly via dedicated signalling based on information determined within the NW.
	+ FFS for both options whether there is a report from the UE to suggest a carrier or provide a metric report

Companies still have divergent views on selection of option 1c or option 2a, based on the proposals from the contributions from [2][6][7][8][9], the following aspects are proposed for the comparison of option 1c and option 2a:

a) DRX support for carrier selection criteria

b) Load balance or UE redistribution

c) Paging carrier selection upon cell change

d) Specification impact; Paging Formula, complexity (different rules) in selecting a carrier by UE

Proposal Selection of option 1c and option 2a should be based on

**a) DRX support for carrier selection criteria**

**b) Load balance or UE redistribution**

**c) Paging carrier selection upon cell change**

**d) Specification impact, Paging Formula, Complexity (different rules)** **in selecting a carrier by UE**

## 2.8 Signaling aspect

For the detailed signaling aspect for paging carrier selection, it should be based on whether option 1c or option 2a will be adopted, thus, it is proposed not to discuss the signaling aspect for now.

# Conclusion

Based on the discussion in the previous sections we propose the following:

Proposal 1 For option1, DRX should be part of the carrier selection criteria. RAN2 to discuss how to combine the DRX criteria with CE level criteria.

Proposal 2 Support carrier specific DRX configurations, including carrier specific *defaultPagingCycle*, *nB,* and *ue-SpecificDRX-CycleMin*.

Proposal 3 For option 1, upon cell change, FFS is needed to choose from Alt 1 and Alt 2.

Proposal 4 Confirm the WA: UE metric for determining carrier suitability and selection is based on measured NRSRP.

Proposal 5 FFS whether to use a hysteresis/longer averaging/timer for UE metric based on NRSRP.

Proposal 6 For both options, there is no need to introduce UE report.

Proposal 7 UE capability for Rel-17 paging carrier selection should be introduced.

Proposal 8 Selection of option 1c and option 2a should be based on

**a) DRX support for carrier selection criteria**

**b) Load balance or UE redistribution**

**c) Paging carrier selection upon cell change**

**d) Specification impact, Paging Formula, Complexity (different rules)** **in selecting a carrier by UE**