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

Electronic meeting, August 16th –27th, 2021

Agenda Item: 9.1.3

Source: Ericsson

Title: [AT115-e][302][NBIOT/eMTC R17] carrier selection (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This paper is intended to gather input from companies on below

* [AT115-e][302][NBIOT/eMTC R17] carrier selection (Ericsson)

 Scope: Progress the above proposals

 Intended outcome: report in R2-2108972

 Deadline: Monday 23rd, 1200 UTC.

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 |

The below Agreements have been made in RAN2#115

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| --- |
| Agreements* Support coverage or carrier specific DRX configurations, FFS details.
* UE capability for Rel-17 paging carrier selection should be introduced
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# 2 Contact Information

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| --- | --- |
| Company | Contact: Name (E-mail) |
| Huawei, Hisilicon | Odile Rollinger (odile.rollinger@huawei.com) |
| Qualcomm | Mungal Dhanda (mdhanda@qti.qualcopmm.com) |
| ZTE | Ting Lu (lu.ting@zte.com.cn) |
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# 3 Discussion

## 3.1 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 (i.e., Alt 2, see agreements in R2-2106602), 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, RAN2 to choose between Alt 1 and Alt 2.

**Input#1 Required for**: Please provide comments below on the preferred Option.

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| --- | --- | --- |
| Company | Preferred Alt | Comments |
| Huawei, HiSilicon | Alt 2 | In the same way that it cannot be guaranteed that the coverage will remain the same in a cell, it cannot be guaranteed that the coverage will remain the same in another cell.To deal with the fact that the NW does not know the coverage of the UE in a cell, the NW will have to page on the two carriers after failure of the first paging attempt. This is acceptable when this is limited to a single cell but will have severe impact on the paging load and paging capacity if the NW needs to page on two carriers in every cell during paging escalation.  |
| Qualcomm | ALT 2 | This is because with ALT2 paging resource usage and latency is not affected when UE changes cell. With ALT1 both latency and paging resource usage can degrade. Also bear in mind, paging carrier selection upon coverage level degrade (i.e., when coverage-based paging carrier is no longer suitable) also needs to be decided and ALT2 also works in this case. |
| ZTE | Alt 1 | We can understand the Alt2 is beneficial in some cases that the coverage of UE changes worse at the same time when the UE moves to another cell. With Alt1, UE and new eNB can simultaneously fallback at the first time paging that can avoid the first time paging failure. But we should note that network can only use the maximum Rmax to perform paging, as legacy, the benefit of R17 scheme is lost.It’s easy to understand in other cases that the coverage of UE keeps unchanged or change better when moving to another cell, Alt 1 is feasible. It’s highly possible the first time paging is successful and the benefit of less Rmax in R17 scheme still can be achieved. Moreover, based on the following further analysis, we assume the cases that the coverage of UE keeps unchanged or change better may be more or even much more:* If UE is assigned with large Rmax in old cell, that means the UE is in bad coverage in the old cell, the UE may be likely to move to another cell. We think it’s highly possible that the coverage would become better in new cell and Alt1 still can be used.
* If UE is assigned with small Rmax in old cell, that means the UE is in good coverage, we assume it’s less likely to move to another cell. Even the UE moves, only in a few sub-cases, the UE’s coverage may change worse. In other sub-cases, the UE’s Rmax still can be valid in the new cell.

Finally, in previous meeting, we already have an agreement that “*Whenever the R17 coverage based carrier criteria is met, UE uses the R17 coverage based carrier, otherwise UE should use the fallback mechanism*”. We think there is intention that in order try to avoid any inconsistence between UE and network, the R17 carrier should be used as possible as it can. For Alt1, only coverage change would strongly require fallback. |
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## 3.2 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.

**Input#2 Required for**: Please provide comments below on the above proposals to confirm the WA.

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| Company | WA is agreeable Yes/No | Comments |
| Huawei, HiSilicon | yes | option b) NPDCCH repetition is a carrier specific metric. it cannot be used to a select one carrier among other.option c). carier selection should be deterministic and testable, it cannot be left to the UE implementation |
| Qualcomm | No | Field data in [3] shows NRSRP alone is not a sufficient metric to determine suitable paging carrier as for the same NRSRP, UE may experience different level of interference hence may result in different number of repetitions required to decode the paging NPDCCH. Therefore, estimation of Rmax over a longer period is much better metric and will provide better paging performance by minimising paging resource usage and latency.Reminder that NPRACH selection has a fast feedback in that (a) timers protecting lack of response from network, (b) measured NRSRP affects immediate action for NPRACH resource selection and does not control what resources UE will use in the future e.g., in 30 mins. For paging resource selection affects system performance. |
| ZTE | Yes | Only when UE’s coverage level become worse, the UE needs to fallback. So the UE mainly need to determine whether the required number of DL repetition is larger than the assigned Rmax. Therefore, besides the RSRP measurement, the required repetition number for receiving DL, e.g., SIB can also be assistance information for UE to do such carrier suitability determination. For simplicity ,we think measured NRSRP is still enough. |
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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.

**Input#3 Required for**: Please provide comments below on the above proposals and your view on the long-term evaluation of UE metric.

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| Company | Comments |
| Huawei, HiSilicon  | We think we cannot use a one shot measurement as the accuracy is not that fine in NB-IoT and the value can fluctuate. we also think that it cannot be left to the implementation. This eliminates option a) and e).We think that the issue is quite similar to cell reselection and that we could reuse a similar approach thus we are in favour of option d). We would be open to consider an hysteresis (option b) if this is the majority preference. We do not see how carrier selection is more critical than cell reselection and justify option c) |
| Qualcomm | There needs to be hysteresis and the hysteresis may need to be different for different cases: (1) When UE initially camps on a cell it should select paging carrier using legacy scheme and after it has obtained sufficient data for then it can switch to a coverage specific paging carrier. (2) When UE has selected a coverage based paging carrier then it needs to have a shorter hysteresis to (but longer than just one or two paging DRX cycles) before it returns to legacy paging carrier, and vice versa. |
| ZTE | For the (2) mentioned by Qualcomm, per our understanding, if CEL-based carrier selection is triggered/enabled, UE can decide whether to fallback just based on the suitability checking results (discussed in #issue2). We cannot see the real usage of a shorter or longer hysteresis to control UE to return to legacy paging carrier.For (1) mentioned by Qualcomm, if companies assume the enable of CEL-based carrier selection can based on UE’s ”report“ (maybe at least UE capability), it’s natural that without such “report”, the network would not assign Rmax or explicit paging carrier to UE. When to provide such “report” can be naturally determined by the UE itself. |
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## 3.3 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.

**Input#4 Required for**: Please input your comments for the above proposal.

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| --- | --- | --- |
| Company | Proposal is agreeable Yes/No | Comments |
| Huawei, HiSilicon | FFS | We think there is no need to introduce a new mechanism. However, we think that at least the reporting of the serving cell NRSRP in MSG5 is useful and could be mandated |
| Qualcomm | No | Based on our input to #2 & #3, UE either needs to inform the network which paging carrier it considers suitable or UE informs the network what Rmax is suitable, depending on whether  |
| ZTE | FFS? | UE’s report during RRC establishment procedure or in connected mode may be useful. But we assume such report is only suggestion or preference, not means UE can decide the Rmax or paging carrier. |
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## 3.4 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

The following proposals are provided:

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| Tdoc | Proposals |
| [2] | **Proposal 5a: It’s suggested to support Option 1c that 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 signaling.****Proposal 5b: The Option 2a that NW indicates the carrier to use explicitly via dedicated signaling is not pursued.** |
| [6] | **Proposal** **10**: RAN2 to agree not to pursue option 1. |
| [7] | **Proposal 1: RAN2 not to consider Option 2a.** |
| [8] | **Proposal 5: The method of paging carrier selection based on a rule configured by the network is preferred.** |

**Input#5 Required for**: Please input your preference and comments.

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| --- | --- | --- |
| Company | Preferred Options | Comments |
| Huawei, HiSilicon | option 2a | We think that the two options are not that different and could be merged together. |
| Qualcomm | 1c | But according to our earlier proposals, both options can work. |
| ZTE | 1c | We firstly re-clarify how the option 1c work with carrier-specific DRX cycle configuration. We think the logic is clear and simple:* If *default DRX cycle* and *ue-SpecificDRX-CycleMin* are configured per coverage, that means for carriers with same Rmax, their *default DRX cycle* and *ue-SpecificDRX-CycleMin* are also same. Then UE only need to select the carrier based on matching carrier’s Rmax with its assigned Rmax.
* There may be also more flexible configuration, e.g., several carriers with same Rmax are configured with different *default DRX cycle* and *ue-SpecificDRX-CycleMin*. The UE can firstly decide a set of carriers whose Rmax matches with UE’s assigned Rmax. Furthermore, UE can calculate the DRX cycle T for each carrier, by using the same rules as that used with cell-specific DRX cycle configuration, e.g., *T = min (default DRX value, max (UE specific DRX value, minimum UE specific DRX value broadcast in system information)).* Finally, UE can choose the carrier which provides the smallest DRX cycle T.

Then we want to reiterate the drawback of option 2a as following:* More fallback scenarios that may reduce the benefit of R17 paging carrier selection scheme;
* Less flexible for handling SIB configuration changes. One company mentions this can be handled by not assigning directly a carrier to the UE but a pointer. We don’t clearly know how. For example, the network have assigned three carriers to all the UEs with a certain Rmax and later network removes one carrier, e.g., the third one. Even the UEs that are assigned with the first two pointers can match with the remaining carriers, at least the UEs assigned with the third pointer should fallback.
* Almost cannot handle UE redistribution (or very inefficiently). In this meeting, more companies mention this issue.
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# Conclusion

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