3GPP TSG-RAN WG2 #114e R2-21xxxxx

Electronic meeting, May 19th – May 27th, 2021

Agenda Item: 9.1.3

Source: Ericsson

Title: [AT114-e][301][NBIOT/eMTC R17] NB-IoT Carrier Selection (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This paper is intended to gather input from companies on below

* [AT114-e][301][NBIOT/eMTC R17] NB-IoT Carrier Selection (Ericsson)

**Scope:** Discussion of open points as per the summary document in [R2-2106466](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_114-e/Docs/R2-2106466.zip).

**Intended outcome:** Report in R2-2106601

**Deadline:** Monday May 24 1200 UTC

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

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [R2-2106380](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2106380.zip) | Network configuration for paging carrier selection | Nokia Solutions & Networks (I) |
| [2] | [R2-2106198](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2106198.zip) | Carrier selection enhancement | MediaTek Inc. |
| [3] | [R2-2105317](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105317.zip) | Further discussion on CEL-based paging carrier selection | ZTE Corporation, Sanechips |
| [4] | [R2-2105544](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105544.zip) | Further discussion on enhanced paging carrier selection and NPRACH carrier selection | Spreadtrum Communications |
| [5] | [R2-2105658](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105658.zip) | Clarification on Paging carrier selection | Huawei, HiSilicon |
| [6] | [R2-2105659](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105659.zip) | Guildelines for the design of coverage based paging carrier selection | Huawei, HiSilicon |
| [7] | [R2-2105642](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105642.zip) | Simplified Static solution | THALES |
| [8] | [R2-2106076](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2106076.zip) | Analysis of Rmax based solution and carrier-based solution | Ericsson |
| [9] | [R2-2105919](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105919.zip) | Considerations on the two paging carrier selection schemes | Qualcomm Incorporated |
| [10] | [R2-2105225](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2105225.zip) | Further analysis on paging carrier selection options | Nokia, Nokia Shanghai Bells |

10 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 Contact Information

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| --- | --- |
| Company | Contact: Name (E-mail) |
| Huawei, HiSilicon | odile.rollinger@huawei.com |
| Qualcomm | mdhanda@qti.qualcomm.com |
| Nokia | Srinivasan.selvaganapathy@nokia.com |
| Sequans | ncayron@sequans.com |
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# 3 Discussion

## 3.1 Legacy Carrier and Rel-17 Paging Carrier Exclusive

[1], [2], [6] and [9] provide analysis on the division of carriers between legacy paging carriers and Rel-17 paging carriers, simple configuration of paging carriers which divides the set of carriers into two groups is proposed as basis for further discussion on paging carrier selection algorithm.

Proposal 1 Rel-17 paging carriers and the legacy paging carriers should be exclusive.

**Input#1 Required for**: Please provide comments below on the above Proposal.

|  |  |  |
| --- | --- | --- |
| Company | Proposal is agreeable Yes/No | Comments |
| Huawei, HiSilicon | Yes | We do not see how they could be common if the Rel-17 carriers have a smaller coverage |
| Qualcomm | Yes | Agree with HW’s comment and also see jjustifications for this can be found in R2-2105919 [9] |
| MediaTek | Yes | If not, UE with a good radio condition and bad radio condition would be mixed in one paging carrier, which basically eliminates the benefit of Rel-17 paging carrier selection |
| Spreadtrum | Yes | To support coverage based paging, the exclusive paging carrier should be configured. |
| Nokia | Yes | As indicated in our discussion papers to obtain the benefits of coverage based paging carrier selection, separate list with shorter Rmax values is essential. |
| Sequans | Yes | Agree with above comments |
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**Summary 1**:

## 3.2 S1 Interface Impacts

[4] and [8] give analysis if there is any S1 interface impact. [4] mentions that there is S1 interface paging impact for option 2. However, [8] analyses that both options would not need changes in S1AP and the changes for paging carrier selection are pertaining to container definition.

Proposal 2 S1AP/NGAP update is needed.

**Input#2 Required for**: Please provide comments below on the above Proposal.

|  |  |  |
| --- | --- | --- |
| Company | Proposal is agreeable Yes/No | tainer |
| Huawei, HiSilicon | No | In our view, for both options, any new information will be added to t *UEPagingCoverageInformation-NB* container, which is carried transparently over S1/Ng interface. thus no interface impact is expected. |
| Qualcomm | No | Same view as HW. In any case impact to S1AP/NGAP should not be the deciding factor when selecting a solution. |
| Spreadtrum | No | For option 2, the new information of the previously assigned paging carrier can be included in the container, which has no impact on the interface. |
| Nokia | No | This need not be considered as explicit proposal. RAN3 interface impact is needed in any of the options for coverage based carrier selection. |
| Sequans | No | Agree with HW |
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**Summary 2**:

## 3.3 Different criteria for paging carrier selection

For paging carrier selection based on coverage level, [3], [4], [6], [8] and [9] further provide analysis on either DRX based paging carrier selection, service-based paging carrier selection, or power boosting impact to paging carrier selection.

Proposal 3 support:

* DRX based paging carrier selection
* service based paging carrier selection
* power boosting impact to paging carrier selection

**Input#3 Required for**: Please provide comments below on the above Proposal.

|  |  |  |
| --- | --- | --- |
| Company | Proposal is agreeable Yes/No | Comments |
| Huawei, Hisilicon | No | For option 2, it is up to NW implementation to use one or another information for the selection  For option 1:  DRX cycle: although we agree that the new carrier may be configured with a shorter DRX cycle, we think for a given coverage/Rmax, they will all have the same DRX cycle. This will also make the solution simpler.  Service based selection: Not sure what is proposed here but we do not support having another level  Power boosting: We think none of the R17 carriers should be configured with power boosting, as they should be better used for enhanced coverage. We can leave the configuration to the NW but we should not having power boosting part of the criteria for carrier selection at the UE |
| Qualcomm | No | *DRX based paging carrier selection* can be supported as this is simple to understand, provides benefit and specification changes are minimal.  But we do not support *service based paging carrier selection* and *power boosting impact to paging carrier selection*. |
| MediaTek | No | DRX based paging carrier selection: with a particular nB configuration, DRX based paging carrier selection can help to reduce the paging latency for UE specific DRX UE  Service based paging carrier selection: we have not seen the exact use case.  Power boosting impact to paging carrier selection: the non-anchor carriers should provide same range of service, power boosting for a certain carrier should not be the factor of paging carrier selection. |
| Spreadtrum | No | DRX cycle based paging carrier selection: in order to better use coverage based paging, the consideration of DRX cycle should be involved in the method of coverage based paging.  Service based paging carrier selection: considering many impacts would be caused, such as the definition of service type, it should not be considered at this stage.  Power boosting: the power boosting should not impact paging carrier selection. |
| Nokia | Partially OK | Coverage level based separation already divides to carriers into two sub-groups. UE configured with shorter DRX cycle if in good coverage level can get the benefit from carriers with shorter Rmax value. Need for explicitly considering DRX cycle as criteria over coverage based carrier selection to be analysed further.  Paging probability information which is already supported in S1-AP/NG-AP interface can be used to have separate carriers for low paging probability and high paging probability. This can be used to reduce the ‘false wake-up’ issues in case if GWUS is not supported.  We don’t see need for power-boost based carrier selection. Because it is already reflected in the repetition level (Rmax ) of the carrier. |
| Sequans | Prefer none, but OK with DRX | Even if agreed, this should be conditioned on option 1 being agreed.  We do not see benefits in selection based on service or power boosting.  We can see some benefit to DRX-based selection, so we are OK to proceed with it if other companies agree and the specification impact isn’t large |
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Summary 3:

## 3.4 How does NW configure/enable (dedicated, broadcast signalling?)

[1], [2], [3], [5] and [10] provide the view that NW configuration for Rel-17 paging carriers should be cell specific parameters, and better to be transmitted by broadcast signaling for both options.

Proposal 4 For both options, NW configuration for Rel-17 paging carriers is indicated in broadcast signalling.

**Input#4 Required for**: Please provide comments below on the above Proposal.

|  |  |  |
| --- | --- | --- |
| Company | Proposal is agreeable Yes/No | Comments |
| Huawei, HiSilicon | yes |  |
| Qualcomm | Yes | Carrier configuration provided in broadcast signalling but enablement done via dedicated signalling. |
| MediaTek | Yes |  |
| Spreadtrum | Yes |  |
| Nokia | Yes |  |
| Sequans | Yes | This would also allow to make NW-controlled carrier changes if needed |
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**Summary 4**:

## 3.5 NW and UE align on the selected Rmax/CE level Option 1

For option 1, [1], [2], [3], [5], [9] and [10] provide the view on how NW and UE align on the selected Rmax/CE level, a list of sub-options could be further discussed.

[1] mentions that UE is allowed to select paging carrier group based on CEL. [2] gives the option that for option 1, UE reports the coverage status or paging carrier selection result to NW by dedicated signalling. While [3] provides that the evaluated CEL/Rmax would be assigned to a UE via dedicated signaling. In [9], UE signals to RAN that it prefers to use an *alternative paging carrier* during step 4, and in step 5, network confirms whether UE is permitted to use the *alternative paging carrier*. Further [5] listed all the above options.

Proposal 5 For option 1, RAN 2 to select between the following sub-options:

* Option 1a: No dedicated signalling, UE selects a carrier based on broadcast criteria only
* Option 1b:
* **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 1d: Network explicitly confirms a suggested paging carrier based on a UE report.**

**Input#5 Required for**: Please provide the acceptable Option(s) for above (can select more than one).

|  |  |  |
| --- | --- | --- |
| Company | Acceptable Option(s) | Comments |
| Huawei, HiSilicon | option 1c) |  |
| Qualcomm | 1d | 1a is not acceptable as network and UE must use the same paging carrier to minimise the need for paging on multiple paging carriers in a cell.  Is 1c and special case of 1b? |
| MediaTek | Option 1d | Not sure about option 1b, seems like option 2  The DL coverage status provided by UE would be more precise. Thus option 1d is preferred. But maybe an explicit confirmation for NW is not necessary, UE and NW can conduct to a same carrier based on the UE report. |
| Spreadtrum | 1a | 1a is enough for this paging carrier selection method. |
| Nokia | 1c and 1d | UE decision for carrier selection should be combination of last known coverage level and current coverage level at the time of PO monitoring. Use of only last known coverage level restricts the benefits of the solution |
| Sequans | 1c, 1d | We are OK with both 1c and 1d.  We would be fine to down select between them now if there is a clear majority, though we feel some more details for each of them would be best.  For example, they could also work in tandem, where 1c could be a fallback case of 1d if no suggestion from UE is available or NW rejects it. on the other hand, in that case just going with 1c is simpler.  1b we are also unsure of the meaning  1a would seem to either require some complicated specification and/or risk of |
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Summary 5:

## 3.6 NW and UE align on the selected Rmax/CE level Option 2

For option 2, [1], [2], [3], [5], [8], [9] and [10] provide the view on how NW assigns a certain paging carrier to UE, a list of sub-options could be further discussed.

[1], [2], [3] and [8] provides the view that eNB assigns a paging carrier to a UE by dedicated signaling. While in [10], it gives another alternative to assign the paging carrier based on UE report. Further in [9], eNB indicates to the UE the criteria for selection paging carriers based on one or more factors, including Paging carrier specific Rmax, Paging carrier specific coverage level, Paging carrier specific DRX and Paging carrier ID.

Proposal 6 For option 2, RAN 2 to select between the following sub-options:

* Option 2a: NW provides the carrier explicitly via dedicated signalling based on information determined within the NW.
* Option 2b: NW provides the carrier explicitly via dedicated signalling based on additional UE metric report.
* Option 2c: NW provides the criteria for carrier selection via dedicated signalling based on one or more factors, including Paging carrier specific Rmax, Paging carrier specific coverage level, Paging carrier specific DRX and Paging carrier ID.

**Input#6 Required for**: Please provide the acceptable Option(s) for above (can select more than one).

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| --- | --- | --- |
| Company | Aceptable Option(s) | Comments |
| Huawei, HiSilicon | option 2a |  |
| Qualcomm | 2b |  |
| MediaTek | Option 2a | Prefer no additional UE report in option 2 to keep the solution simple. |
| Nokia | 2c | Additional information is needed to decide on the fallback carrier. |
| Sequans | 2a (preferable), 2b | 2a is basically the fallback of 2b with no additional reporting. We would prefer to keep option 2 as simple as possible unless additional reporting can be positively shown to bring significant additional benefits  Not quite sure about 2c, it looks either very complicated or basically option 1 |
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Summary 6:

## 3.7 How does UE select carrier, based on what criteria and metrics?

Further, [2], [3], [4], [5], [8], [9] and [10] discuss the metric for UE to determine carrier suitability and to select paging carrier, a list of alternatives has been provided.

Proposal 7 For both options, UE metric for determining carrier suitability and selection is based on one of the alternatives:

* Alt 1: measured NRSRP.
* Alt 2: estimated Rmax.
* Alt 3: long-term evaluation of radio condition over multiple paging occasions.

**Input#7 Required for**: Please provide the acceptable Option(s) for above (can select more than one).

|  |  |  |
| --- | --- | --- |
| Company | Acceptable Option (s) | Comments |
| Huawei, HiSilicon | alt.1 | For carrier selection, we do not see how Rmax (which is carrier specific) can be used. |
| Qualcomm | Alt 3 | Our understanding is Alt 1 & Alt 2 are measurements for one PO and we think this can lead to a lot of ping-pong with paging carriers, or UE moves to fallback carrier and remains there (depending on what RAN2 decides on movement between fallback and coverage based paging carrier) |
| MediaTek | Alt 1 | NRSRP is enough for this case. |
| Spreadtrum | Alt 1 | Same view as MediaTek. |
| Nokia | Alt 1 | RSRP is already used for CEL based RACH pool selection. Considering the Rmax difference between the carriers are sufficiently high and only limited sub-groups possible based on coverage leve, Alt 1 is sufficient. |
| Sequans | Alt 3 | Agree with QC. |
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Summary 7:

## 3.8 What happens upon cell change?

Upon cell change, [2], [3], [4], [5], [6], [9] and [10] provide the view for option 1. Two alternatives are provided.

Proposal 8 For option 1, upon cell change:

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

**Input#8 Required for**: Please provide the preferred Option for above.

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| Huawei, HiSilicon | Alt2 | Alt2 is the simpler  Alt1: we could eventually accept it with an additional condition that the NW authorizes the UE via dedicated signaling to use the scheme in another cell |
| Qualcomm | Alt 2 | Also see our response to Proposal 11. |
| MediaTek | Alt 1 | Alt 1 is better for mobile UE and the cost is acceptable. |
| Spreadtrum | Alt 1 | For option 1, the cell change has no direct impact on paging carrier selection. We only concern whether CEL changes or not in this option. |
| Nokia | Alt 1 | In new cell, whether the UE can select carrier based on its CEL depends on how the network starts the non-serving-cell paging and starting CEL. If the NW decides to start the CEL in non serving cell from best coverage level, then UE selection based on CEL will work without issues (there could be paging delay). But if network decides to start the paging from specific repetition level UE may need to align to avoid missing of paging.  As Huawei indicated, this option requires additional signalling for NW control.  Alt2 restricts the benefits of coverage-based carrier selection only to stationary devices. |
| Sequans | Alt 2 | Alt 2: Simple and conservative with NW resources  Alt 1: Even assuming simplest NRSRP-based selection is agreed, this would only be feasible in the cases when UE is mobile and still its coverage conditions didn’t change; otherwise, NW has no way of knowing which carrier the UE selected and would have to page on all of them.  In addition, this sounds completely unscalable. If agreed, it should probably be limited to a single cell change.  All in all, this is a lot of complication for not much gain.  This is also not feasible if long-term quality estimation is agreed. |
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Summary 8:

Upon cell change, [2], [3], [4], [5], [6], [8], [9] and [10] provide the view that for option 2, UE needs to perform fallback mechanism.

Proposal 9 For option 2, upon cell change, UE needs to perform fallback mechanism.

**Input#9 Required for**: Please provide if above Proposal is correct.

|  |  |  |
| --- | --- | --- |
| Company | Proposal correct Yes/No | Comments |
| Huawei, HiSiicon | Yes |  |
| Qualcomm | Yes | Also see our response to Proposal 11. |
| MediaTek | Yes |  |
| Spreadtrum | Yes |  |
| Nokia | No | Is this proposal, subset of proposal 8 ? We see need for NW controlled behaviour for the fallback mechanism for cell change scenario. |
| Sequans | Yes | See also previous question |
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Summary 9:

## 3.10 What happens upon coverage change?

[2], [3], [4], [5], [6], [8], [9] and [10] provide the view that when radio condition remains or gets better, UE should remain on the current paging carrier; when radio condition gets worse, UE should adopt the fallback scheme.

Proposal 10 For both options, upon coverage change within the cell:

* When radio condition remains or gets better, UE should remain on the current paging carrier.
* When radio condition deteriorates, UE should adopt to fallback mechanism.

**Input#10 Required for**: Please provide comments below on the above Proposal..

|  |  |  |
| --- | --- | --- |
| Company | Proposal is agreeable (yes/no) | Comments |
| Huawei, HiSilicon | 1st bullet : maybe  2nd bullet: yes | For the first bullet, it is not clear what ‘the current paging carrier’ is.  - For the selected R17 paging carrier, we agree.  - For the fallback paging carrier, we disagree. |
| Qualcomm | Yes | Following option is unclear what it means:  *• When radio condition remains or gets better, UE should remain on the current paging carrier.*  If UE was on fallback carrier and coverage becomes suitable for coverage based paging carrier then we think UE should switch to coverage based paging carrier. This is not clear from the first bullet.  Yes to second bullet i.e. when radio condition deteriorates. |
| MediaTek | yes |  |
| Spreadtrum | Yes |  |
| Nokia | Yes |  |
| Sequans | Yes | We understand these options together to mean UE may only *autonomously* change carrier to fallback carrier (UE doesn’t change carriers to another coverage-based carrier)  We added autonomously for the case where e.g. SI information change causes UE to switch carrier of the same equivalent allocation |
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Summary 10:

## 3.11 Details of the fallback carrier

[2], [3], [4], [5], [6], [8], [9] and [10] provide the view on which carrier should be configured as fallback carrier. Two alternatives are provided.

Proposal 11 For both options, fall back carrier should be configured as:

* Alt 1: legacy paging carrier based on UE\_ID
* Alt 2: network configured specific carrier other than the dedicated paging carrier

**Input#11 Required for**: Please provide the preferred Option for above.

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| Huawei, HiSilicon | alt 1 |  |
| Qualcomm | Alt 1 |  |
| MediaTek | Alt 1 |  |
| Spreadtrum | Alt 1 |  |
| Nokia | Alt 1. OK for Alt2 as additional option. | As dedicated signalling is already considered for paging carrier selection, supporting possibility of selecting legacy carrier from NW for paging also can be considered. But the benefits of such enhancement needs to be established. |
| Sequans | Alt 1 |  |
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Summary 11:

# Conclusion

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

TO BE UPDATED LATER

Proposal 1 For both options, RAN2 to discuss whether Rel-17 paging carriers and the legacy paging carriers should be exclusive.

Proposal 2 For both options, RAN 2 to discuss if S1AP update is needed.

Proposal 3 RAN 2 to discuss and decide whether and how to support:

* DRX based paging carrier selection
* service based paging carrier selection
* power boosting impact to paging carrier selection

Proposal 4 For both options, NW configuration for Rel-17 paging carriers is indicated in broadcast signalling.

Proposal 5 For option 1, RAN 2 to select between the following sub-options:

* Option 1a: No dedicated signalling, UE selects a carrier based on broadcast criteria only
* Option 1b: Network enables UE to select a R17 paging carrier by enabling per UE in dedicated signalling.
* **Option 1c: Network enables UE to select a R17 paging carrier by providing the coverage information (CEL/Rmax) for the carrier selection to the UE in dedicated signalling**
* **Option 1d: Network explicitly confirms a suggested paging carrier based on a UE report.**

Proposal 6 For option 2, RAN 2 to select between the following sub-options:

* Option 2a: NW provides the carrier explicitly via dedicated signalling based on information determined within the NW.
* Option 2b: NW provides the carrier explicitly via dedicated signalling based on additional UE metric report.
* Option 2c: NW provides the criteria for carrier selection via dedicated signalling based on one or more factors, including Paging carrier specific Rmax, Paging carrier specific coverage level, Paging carrier specific DRX and Paging carrier ID.

Proposal 7 For both options, UE metric for determining carrier suitability and selection is based on one of the alternatives:

* Alt 1: measured NRSRP.
* Alt 2: estimated Rmax.
* Alt 3: long-term evaluation of radio condition over multiple paging occasions.

Proposal 8 For option 1, upon cell change:

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

Proposal 9 For option 2, upon cell change, UE needs to perform fallback mechanism.

Proposal 10 For both options, upon coverage change within the cell:

* When radio condition remains or gets better, UE should keep on the current paging carrier.
* When radio condition deteriorates, UE should adopt to fallback mechanism.

Proposal 11 For both options, fall back carrier should be configured as:

* Alt 1: legacy paging carrier based on UE\_ID
* Alt 2: network configured specific carrier other than the dedicated paging carrier