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

**1th November – 12th November 2021**

**Agenda item: 9.1.3**

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

**Title: Report of [AT116-e][304][NBIOT/eMTC] NB-IoT carrier selection (ZTE)**

**Document for: Discussion and Decision**

# Introduction

This document is the report of the offline email discussion “*[AT116e][304][NBIOT/eMTC] NB-IoT carrier selection*”, as indicated below:

* *[AT116e][304][NBIOT/eMTC] NB-IoT carrier selection (ZTE)*

*Scope: Clarify option 1c details including cell change. Decide between option 1c and 2a.*

*Intended outcome: Report in R2-2111394 and decision between 1c and 2a.*

*Deadline: Monday 8 Nov 1200 UTC.*

# Contact information

Please provide your contact information when feedback:

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# Discussion

In the email discussion “*[post115-e][302] [NBIOT/eMTC R17] carrier selection*”, many aspects have been discussed for the following two options, and also the two alternatives for cell change case of Option 1c:

* Option 1c: Network enables UE to select a Rel-17 paging carrier by providing the “coverage level” information (Rmax/CEL) for the carrier selection to the UE in dedicated signaling. And for cell change case:
  + - Alt1: UE selects a paging carrier based on previously assigned “coverage level” (if CEL change not happen) and broadcasted paging carrier configuration in the new cell.
    - Alt2: fallback to legacy carrier selection scheme.
* Option 2a: Network indicates the carrier to use explicitly via dedicated signaling based on information determined within the NW.

But no consensus have been achieved on which option and which Alt to choose.

In this email discussion, question Q1~Q6 are mainly to clarify the unclear aspects of both options, to align the companies’ understanding etc. There is no intention to make proposals from these questions. Only Q7 would need proposal.

## R17 carrier list configuration in SIB

Rapporteur has no intention to discuss in details on SIB configuration in this email discussion. But since SIB configuration would be part of each option, it’s better for companies to have some consistent assumption/understanding on what SIB configuration for R17 carrier list would look like.

Based on Rapporteur’s knowledge from previous discussion and companies’ contributions, both Option 1c and Option 2a may need the following (simple) configuration for R17 carrier list (called **list\_A** which would be used in the following sections) in SIB (here is just high level assumption, no any preference for the configuration way in ASN.1):

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

Some companies may think there may be additional mapping table in SIB for both options. As this is more related to the below questions Q3 and Q4. We don’t discuss this in Q1. Companies can provide their views in Q3 or Q4.

**Q1: Do companies agree that there would be same R17 carrier list configuration in SIB (taking the above as example) for Option 1c and Option 2a? If not, please indicate what’s the main difference in your assumption.**

(for example, you make think R17 carrier list configuration would be different for Option 1c and Option 2a, or you make think even they can be same, the *nB* (or some other parameters) should be carrier specific, not coverage specific etc. Then you can say No, and give some clarification.)

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| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We are fine to introduce coverage specific DRX cycle. It can be uniquely determined when a paging carrier is selected/assigned. It would be used in the places where previously cell-specific default paging cycle is used.  We are also ok not to introduce such parameter and to still use cell-specific default paging cycle. |
| Nokia | Yes. But | Coverage level in terms of RSRP is needed for each or group of Rel-17 carriers in system information. This is also needed for both options. Because for the UE to decide on fallback to legacy carriers based on the coverage level information, this information is essential. In case of 1C this threshold is used for selecting carrier matching the threshold value. In case of 2a whether UE can monitor the same carrier or not needs to be decided based on RSRP level. |
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**Conclusion:**

## Usage of the assigned Rmax or paging carrier in UE

Per Rapporteur’s understanding, for both Option 1c and Option 2a, after determining the suitability of the assigned Rmax or assigned paging carrier, UE can make use of such Rmax or paging carrier as below:

* For **Option 1c**, based on the **list\_A,** UE constructsa sub list (called **sublist\_A**) of coverage-based paging carriers that match the UE’s assigned Rmax (e.g., in one example, if UE is assigned with Rmax X, then all coverage-based paging carriers with configured *npdcch-NumRepetitionPaging* >=X are candidates; In another example, only paging carriers with configured *npdcch-NumRepetitionPaging* =X can be candidates, that imply the assigned Rmax to UE should be in the value scope of the *npdcch-NumRepetitionPaging* configured to R17 paging carriers).
  + UE uses the legacy UE\_ID based formula to select one paging carrier from this **sublist\_A.** And then UE monitors the selected paging carrier on the PO, applying the *nB*, *ue-SpecificDRX-CycleMin* and (optional) coverage specific DRX cycle of this carrier.
* For **Option 2a**, the UE can directly monitor the assigned paging carrier on the PO
  + Before that, the UE needs to find this paging carrier in the **list\_A** (e.g., by matching the absolution EARFCN or matching kind of index/pointer), then the UE can use this carrier and apply the *nB, ue-SpecificDRX-CycleMin* and (optional) coverage specific DRX cycle of this carrier.

Please note Rapporteur as proponent of Option 1c try to give some detailed thinking about Option 1c, just for convenience for companies’ understanding. It’s certainly possible companies can disagree/concern something and please indicate in below table.

**Q2: Do companies agree the above assumption on the usage of the assigned Rmax or assigned paging carrier in UE? Any disagreement or concern can be indicated in the table (please avoid talking about too many details that can be left to Stage-3 discussion).**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes |  |
| Nokia | Yes | OK. But not sure about the relevance of this question here. In our understanding the selection of carrier at the time of PO is based on RSRP measurements at the time of PO reception. This measurement and decision is needed in either option. After the selection as described above UE can make use of Rmax and other values of the paging carrier. |
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**Conclusion:**

## UE metric for determining the suitability of the assigned Rmax or carrier

Per Rapporteur’s understanding, for Option 2a, most companies can agree UE metric is needed for determining the suitability of the assigned paging carrier before performing the process mentioned in section 3.2.

For Option 1c, proponent companies (**company A**) also mention UE metric is needed for determining the suitability of the assigned Rmax before performing the process mentioned in section 3.2, which would be same as that for checking the suitability of the assigned paging carrier in Option 2a. Meanwhile, companies (**company B**) think it’s unclear for Option 1c on how to perform this as they assume UE needs to check both NRSRP and the assigned Rmax when UE builds the list of candidate paging carriers.

As we have no any detailed progress on the UE metric based on NRSNP, it’s hard to exactly know the reason for such different understanding between company A and company B.

Here Rapporteur try to figure out something. Rapporteur understand **company B** firstly may have an assumption that a NRSRP threshold would be assigned for each paging carrier (either in SIB or in dedicated signaling along with the assigned paging carrier). Following such assumption, Rapporteur try to compare as following (for Option 1c):

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|  | **company A** | **company B** |
| a NRSRP threshold is assigned for each paging carrier in SIB  (signalling efficient way) | company A may have the further assumption that assigned NRSRP would be same for all the paging carriers configured with the same *npdcch-NumRepetitionPaging:*   |  |  |  | | --- | --- | --- | | f1 | Rmax-1 | NRSRP-1 | | f2 | Rmax-1 | NRSRP-1 |   Based on that, UE (assigned with Rmax-1) can perform:  If current NRSRP >assigned NRSRP for a npdcch-NumRepetitionPaging  use assigned Rmax to select carrier  else use legacy carrier | company B may have the further assumption that assigned NRSRP could be different for the paging carriers configured with the same *npdcch-NumRepetitionPaging:*   |  |  |  | | --- | --- | --- | | f1 | Rmax-1 | NRSRP-1 | | f2 | Rmax-1 | NRSRP-2 |   Then company B may think, the UE (assigned with Rmax-1) would be unclear which value (NRSRP-1 or NRSRP-2) can be used to compare with the current NRSRP. |
| a NRSRP threshold is assigned along with the assigned Rmax/paging carrier in dedicated signalling | If current NRSRP > assigned NRSRP  use assigned Rmax to select carrier  else use legacy carrier | Rapporteur assume company B also think it’s clear for Option 1c in this case. If Rapporteur have wrong understanding, it can be indicated below. |

Based on the above analysis, Rapporteur suggest the following compromise ways:

* **Way1:** For Option 1c, UE can firstly perform paging carrier selection mentioned in section 3.2 and then use same UE metric to determine the suitability of the selected paging carrier. If not suitable, UE can use legacy carrier.
* **Way2:** If UE metric includes an assigned NRSRP threshold for each carrier in R17 carrier list in SIB, such assigned NRSRP threshold can be same for all R17 paging carriers with the same *npdcch-NumRepetitionPaging*. (here the assumption is that the assigned NRSRP threshold in SIB can be coverage specific, not carrier-specific. But if company think the assigned NRSRP threshold must be carrier-specific, please clarify the reason in the following table)

Based on the above analysis, Rapporteur think UE metric/mechanism for determining the suitability of the assigned paging carrier or assigned Rmax/selected paging carrier can be same. And the details of UE metric can be discussed later.

**Q3: Do companies agree same UE metric/mechanism can be defined for determining the suitability of the assigned Rmax (or selected paging carrier based on assigned Rmax) in Option 1c or the assigned paging carrier in Option 2a?**

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| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes | We slightly prefer to have assumption mentioned in **Way 2**. It’s a simple way as we see no clear motivation for different “*NRSRP threshold”* for the carriers configured with same *npdcch-NumRepetitionPaging*.  Even if we may have other kind of UE metric later, we guess such assumption can also be applied. |
| Nokia | Yes | For both options RSRP threshold for considering Rel-17 carrier for PO reception is needed. In case of option 1C, it is directly used for selecting sub set of carriers meeting the given threshold for further selection based on UE-ID. For option 2C without RSPR threshold fallback is not possible. Here the RSRP threshold can be assigned as common parameter for Rel-17 carriers so that fallback can be checked first based on this before using the assigned carrier for PO reception.  **In summary: Use of RSRP Threshold as criteria for the decision of carrier selection is needed for both options. How this criteria is used for selection only differs for options,** |
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**Conclusion:**

## Uniform distribution among R17 carriers

During email discussion, one of the main concerns for Option 2a is inefficient or infeasible UE redistribution when SIB change happens (adding a carrier, removing the carrier or changing the Rmax configuration of a carrier etc.).

As different companies have different views on the necessity of handling such cases and there are already much discussion in previous email discussion, Rapporteur would not ask question about necessity of solutions. Let’s focus on the solutions themselves. Per Rapporteur’s understanding, as uniform distribution among paging carriers is a legacy function from R14, no company think it’s not needed. But some companies just think it’s not critical. Anyway, if some companies still want to insist that no need to find solution on this aspect for Option 2a, you can indicate comments in Q4.

During email and online discussion, most companies agree that **Option 1c** can handle UE redistribution as legacy.

For Option 2a, some companies mentioned they have given solutions for **Option 2a**. In the below, rapporteur cite all the mentioned solutions:

* **Solution1: (Sequans comments for Q3 in [R2-2109911])**: *For option 2a, it can also easily be solved e.g. if the indicated index is relative rater than constant (though there may be other solutions); for example, instead of “select 4th carrier in SIB list”, the indication could mean “select the carrier in the 7th percentile group” which would result in the 4th carrier if there are 5 carriers in SIB or the 5th carrier if there are 6.*
* **Solution2: [R2-2109912] (Ericsson)**: *First of all, the possibility of system information change is small, and if it happens, UE can fall back to legacy paging carrier, which is easy and straightforward…….Another solution for this problem for option 2 is that it can simply be addressed by assigning an index number to each carrier so that the NW can assign the index number to a UE and when a carrier has to be replaced with another one only the mapping between the index value and the paging carrier needs to be changed. The mapping can be broadcasted in the serving cell.*
* **Solution3: (Huawei comments for Q4 in [R2-2109911]):** *The case where the eNB wants to change a assigned carrier or remove it completely can be handled by an indirection table, i.e. instead of assigning a pointer to a carrier, the eNB assigns a index to a table (signalled in the SIB) which entries point to a carrier. In this way, the eNB can change the assigned carrier or remove it completely by removing the mapping in which case the UE uses the legacy mechanism.*

At least for **Solution2**, the corresponding case is that “*when a carrier has to be replaced with another one”*. Per rapporteur’s understanding, such case is different from the problematic case mentioned as below:

* **[Comment ZTE for Q4 in [R2-2109911]]**: *The UE may not be assigned actual carrier and instead assigned with a pointer. The mapping relationship between the pointers and the carriers is included in a mapping table which needs to be broadcasted as part of system information. Previoulsy we already give an example that shows the pointer scheme infeasible: 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 re-match with the remaining two carriers, at least the UEs assigned with the third pointer cannot find valid carrier and still has to fallback.*
* **[Comment ZTE2 for Q4 in [R2-2109911]]**: *for Option 2a,…., Then a mapping table between the pointers and the carriers would be mandatory in SIB for Option 2a. But even this is the case, the (unnecessary) fallback might be reduced but not completely avoided.*

Based on the further information, companies are invited to provide comments for the following question.

**Q4: Do companies agree that at least one solution is feasible to avoid fallback and achieve uniform distribution among R17 carriers for Option 2a? If Yes, please indicate which solution or maybe a new one. If No, please justify your view.**

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| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | No | * We think solution1 is infeasible as it cannot guarantee UE and eNB select the same carrier/index in SIB (we assume the selection among the percentile group would be based random number). Moreover, this solution also deviates from the original intention of Option 2a, e.g., explicitly assigning a paging carrier. * In the case of removing a carrier, Solution2 cannot avoid that UEs in one carrier (maybe not the removed carrier, but another carrier) fallback to legacy carrier. In the case of adding a carrier (e.g., 3 carriers change to 4 carriers for a certain Rmax), we think it’s possible (depending on how to assign the index to the carriers in SIB) that the UEs previously in carriers #1, #2 and #3 change to other three carriers, e.g., #1, #2 and #4 or carriers #1, #3 and #4. But it may be impossible to let UEs distribute on all the 4 carriers. * We are not so clear about Solution 3 but just feel it’s similar as Solution 2. |
| Nokia | Neutral | In our view this issue is not critical. Simpler solution would be that in case if assigned carrier is not there in the Rel-17 system information list at the time of PO reception, UE should monitor Legacy carriers as fallback solution. We assume the UE may get right carrier after its next uplink transmission. This would be sufficient to handle this situation. For option 2A, it will be similar to cell change scenario. While we agree that there are drawbacks for solution 2A for this scenario compared to 1C this cannot be deciding criteria as it is related to less probable scenario.  As indicated by Ericsson for some scenarios, the index can be assigned if the carrier frequency at the same index is replaced with another carrier frequency with same characteristics for paging configuration. It will be upto network implementation to ensure this.  If carrier is to be really removed without replacing other carrier at the index, SIB can indicate whether fallback to be used or not on change of list as additional parameter. |
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**Conclusion:**

## Alt1 vs Alt2 for Option 1c

During the email discussion “*[post115-e][302]”*, there are already much discussion on pros and cons for Alt1 and Alt2. Here Rapporteur just cite some main concerns for Alt1 and its response in [R2-2109911] for reference:

**Table 3.5-1**

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|  | Concerns for Alt1 | Response |
| #1 | (for Alt1) *“network will have to first page on coverage-based paging carriers in the neighbour cells and if no response then page on legacy paging carriers in the neighbour cells (or alterntively page on both legacy and coverage-based paging carriers in the neighbour cells). In the end there is high probability that more paging resources will be used in the neighbour cells compared to legacy UEs.”*  *“Option 1c Alt 1 can be very costly as it implies double paging in every cell after the 1st attempt.”* | (for Alt2) “*new eNB can only use the maximum Rmax (as legacy) to perform paging. The benefit of R17 scheme is lost. From this perspective, it's not easy to conclude that Alt2 fallback mechanism is definitely better than Alt1 for saving paging resources*.”  (It’s also possible that 1st air interface paging attempt are sent in all the cells) “*it’s obviously that Option 1c with Alt2 or Option 2a would consume more air interface resources in all the other cells*”.  “*the first paging message on the coverage-based carrier has a good chance of succeeding, therefore it could save resources and improve the latency due to the shorter Rmax value. If it does not succeed, the following paging* *messages will be sent in the legacy carrier. It can cost more resources and increase the latency in this case, but considering the chance should be rare, the total benefit should still be positive.*” |

Rapporteur also list some further thoughts on Alt1 mentioned by companies. There is no any intention to trigger discussion on Alt1 or to figure out a detailed Alt1 solution. The only purpose is just for reference, e.g., in case companies may think the feasibility of Alt1.

**Table 3.5-2**

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|  | Company/Tdoc | Related proposals |
| #A | MediaTek comments for Q1 in [R2-2109911] | we propose a compromised solution. It is to introduce an enabling flag in system information, notifying the UE with a coverage configuration from NW and it has just selected this cell (i.e., not for the UEs that are already monitoring the paging carriers) if it should fall back to a legacy carrier for paging messages, or if it is allowed to select the coverage-based carrier if the coverage is still good enough. NW can toggle this flag in the case of coverage-based carriers being overburdened |
| #B | [R2-2110148] (Nokia) | Proposal 1: Coverage based carrier selection should be applicable on any cell. After cell reselection UE can choose any carrier based on its determined coverage level at the time of paging occasion.  Proposal 2: Network configuration of controlling paging carrier selection after cell reselection is supported to align this configuration based on network paging strategy. |

The above is just summary on the related information in order to facilitate companies to make choice in Q7.

**Q5:** Companies can give further (short) comment if they have, e.g., in case they think some response in Table 3.5-1 are unreasonable or some proposals in Table 3.5-2 are infeasible.

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| **Company** | **Additional comment(s)** |
| ZTE | We are open to discuss a control indication for Alt1 in SIB (both #A and #B in **Table 3.5-2**). That may means Alt1 would not be used by default even the UE determines the suitability of the assigned Rmax in the new cell. |
| Nokia |  |
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**Conclusion:**

## Other aspects

During the online discussion, companies have mentioned that Option 1c is better for addressing the paging issues.

**Q6a: Do companies agree the above view?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comment(s)** |
| ZTE | Yes |  |
| Nokia | Yes | As indicated in our discussion paper, primary motivation for coverage based paging carrier selection is to have better paging reception performance for UE in good coverage which otherwise was impacted due to configuration restrictions of extended coverage UE. Moreover most of the mobile UE are expected to be in normal coverage and their coverage condition will not change drastically in most of the cases during cell change.  **Observation 1: For the practical mobility scenarios the coverage condition change during cell reselection is not significant. With assignment of RSRP value to allow such variation it is possible that UE will select same set of paging carrier after cell reselection.**  Paging strategy is network implementation option. For NB-IoT, when the system decides to page for UE after failure in last connected cell, for optimum resource usage it is expected to start with same number of R value as known in last cell for this purpose. Instead of using Rmax which will increase the resource usage if it is to be sent in multiple cells. If this approach is used in legacy cases, it can be also used for Rel-17 with difference that this first attempt happens over different carrier.  **Observation 2: It is feasible to continue with coverage based paging carrier selection after cell change for some network implementations without impacting paging reception for UE in normal coverage mobility scenarios.**  **Hence restricting the feature benefit which is primarily targeted for normal coverage UE to only in serving cell is not needed as the mobility scenario is mostly associated with normal coverage UE. So compromised solution of network control on fallback or continue with coverage based carrier selection for cell-change/coverage scenario is needed.** |
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**Conclusion:**

Besides all above mentioned aspects, Rapporteur understand there is almost no controversy on the other issues, e.g., load balancing performance, main content in the dedicated signaling. But if companies think there is still other unclear aspects for any option, please indicate in the following table.

**Q6b: Any other unclear aspect?**

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| **Company** | **Additional comment(s)** |
| Nokia | In our view, Option 2A is not orthogonal option to Option 1C. If network configures one or two sub-set of paging carriers as similar to RACH-Pool for different extended coverage scenarios, within the sub-set network can still assign specific carrier via network control if network wants to decide on the carrier considering other attributes. But the benefit difference against option 1C is only the network control over UE distribution. So this additional option is not needed unless other benefits of such network selection is established. Otherwise base solution where UE selecting subset of paging carriers based on RSRP threshold is sufficient to meet work item objective. |
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**Conclusion:**

## Choice for option

Based on all the above clarification on the unclear technical aspects of Option 1c and Option 2a, companies are invited to give your clear choice on the following options.

**Q7: Companies are invited to provide your choice on the following Options:**

* **Option A: Option 1c + Alt1 (Keep using R17 scheme (if CEL change not happen) when cell change)**
* **Option A1: Option 1C + Network control on fallback for cell-change scenario**
* **Option B: Option 1c + Alt2 (fallback when cell change)**
* **Option C: Option 2a**

(Rapporteur note:

* The choice for Option A and Option B would be counted together as the support of Option 1c, as both of them are feasible in the context of Option 1c (the only issue is trade-off between benefit and resource waste).
* Furthermore, Rapporteur assume **Option B (Option 1c + Alt2)** would be acceptable to all the supporters of Option 1c. In order try to avoid repeated discussion, if Option 1c can be agreed,we can have a further working assumption that **Option B (Option 1c + Alt2)** would be specified if no acceptable detailed Option A can be achieved.)

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| --- | --- | --- |
| **Company** | **Option A or**  **Option B or**  **Option C?** | **Additional comment(s)** |
| ZTE | Option A | Option B is also acceptable to us. |
| Nokia | Option A1 | If Option A1 is not acceptable we don’t see major difference between Option B and Option C. Selecting Option B or Option C will restrict the feature applicability to serving cell. As it is feasible to support Option A in some cases better to allow the option to enable instead of ruling out this option from specification. |
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**Conclusion:**

**Proposal:**

# Conclusion

**TBD**

# References

[1] R2-2109911, Report of email discussion [302] [NBIOT/eMTC R17] Carrier Selection, Ericsson, RAN2#116e

[2] R2-2109912, Analysis of Rmax based solution and carrier-based solution, Ericsson, RAN2#116e

[3] R2-2110110, Option1c for CEL-based paging carrier selection, ZTE Corporation, Sanechips, RAN2#116e

[4] R2-2110148, Paging strategy impacts for coverage based paging carrier selection, Nokia, Nokia Shanghai Bells, RAN2#116e

[5] R2-2110149, Network configuration for paging carrier selection based on coverage level, Nokia, Nokia Shanghai Bells, RAN2#116e

[6] R2-2110191, Further discussion on enhanced paging carrier selection, NEC Corporation, RAN2#116e

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[8] R2-2110694, Further consideration on open issues for coverage-based paging carrier selection, Qualcomm Incorporated, RAN2#116e

[9] R2-2110695, Signalling for coverage-based paging carrier selection, Qualcomm Incorporated, RAN2#116e

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