3GPP TSG-RAN WG2 #112e R2-20xxxx

Electronic meeting, November 2nd – 13th 2020

Agenda Item: 9.1.3

Source: Ericsson

Title: [AT112-e][302][NBIOT R17] Carrier selection (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

The document aims to collect the views for below email discussion and to provide summary

* [AT112-e][302][NBIOT R17] Carrier selection (Ericsson)

Scope: Discuss what coverage information to use and whether DRX information can be used.

Intended outcome: Report in R2-2010906

Deadline: Tuesday 10th 1200 UTC

# 2 Discussion

In Rel-17 one of the objectives in the WID is:

* Introduce support for NB-IoT carrier selection based on the coverage level, and associated carrier specific configuration (e.g. maximum repetitions UL/DL, DRX configurations, etc.). [NB-IoT] [RAN2, RAN3]

In RAN2-111e it was decided that the scope or focus area is as below:

Agreements

* Paging carrier selection Improvements based on CE level is considered
* Paging carrier selection Improvements based on DRX cycle may be considered
  + whether DRX cycle is considered as part of CE level (Rmax) or can be also considered separately
* Enhancements for NPRACH Carrier selection carrier may be considered
* Paging carrier selection Improvements solely based on WUS or GWUS is not considered
* FFS service based

In RAN2-112e companies briefly discussed that the term CE level terminology as such is coverage level and not directly related to NPRACH CE level.

## 2.1 Coverage Information

In order to support paging improvements based upon coverage level information, RAN2 need to first decide on what metric the coverage should be based upon. The UE coverage level is a dynamic attribute, and this may change if NRSRP changes. How the UE should detect the intra-cell coverage condition change and how to decide if the current paging carrier is no longer good enough and needs to be changed. How the coverage level is judged? This should be discussed. There may be number of alternatives for example:

* Alt1: based on NRSRP
* Alt2: an estimated BLER for decoding NPDCCH considering a certain paging Rmax being above a certain percentage threshold, e.g. 1 or 10%, similar to what is already done for Msg3 CQI reporting.
* Alt3: NPDCCH repetitions evaluated by eNB.
* Alt4: A high level information reflecting the service requirements/ characteristics negotiated between the UE and MME/AMF via NAS, e.g. ‘normal coverage’, etc.

Companies are invited to provide their view on coverage level definition.

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| Company | Comments |
| Huawei, HiSilicon | In general, we think there are two options to define the coverage information used for paging carrier selection. For both options, the UE and the eNB need to be aligned with each other:   * RAN level information, i.e. the first two bullets:   For RAN level information, the eNB and the UE can align with each other in the previous RRC connection. For example, if NRSRP is used, the UE needs to report it to the eNB. If repetition number for decoding NPDCCH is used, the eNB can configure a value to the UE based on connected mode transmission before the release.   * High level information, i.e. the last bullet:   The information can be negotiated between the UE and MME/AMF via NAS, similar to WUS assistance information or eDRX parameters, and be provided to the eNB with the Paging Request.  We think both options can work but the following two issues need to be considered:   * Mobility. RAN level information can only be used in the “last used cell”. A moving UE may have good coverage also in the new cell. * Coverage change. For RAN level information, UE accessing only for coverage report in IDLE mode should be avoided as it will cause UE power consumption. Thus we need to define a mechanism to handle this case. For high level information, it can be updated by NAS signaling if changed. Since it is related to UE’s service requirement, we assume it will only need to be updated occasionally as eDRX cycle and paging probability.   Based on above, we prefer a high level coverage information. |
| ZTE | For Alt4, we are not so clear why and how CE level could be related to UE’s service requirement? Generally, CE level is only related to radio conditions of the environment where the UE is located. Only one exceptional case is Enhanced Coverage Restricted function in which the UE is restricted from using the enhanced coverage feature based on its subscription, regardless it’s real radio condition. But as enhanced coverage is a basic feature for NB-IoT, we assume enhanced coverage restricted UEs would only be corner case. In a summary, if we don’t just consider enhanced coverage restricted UEs (e.g., normal UEs with low mobility are also considered), we think it’s not reasonable to define high level information for CE level.  Previously we also have mentioned it may be possible that CE level can be negotiated via NAS. But in our thoughts, it’s still a radio condition-related information, not so-called high level information. Furthermore, as we think such NAS scheme needs RAN3/SA2 specification works and CE level negotiation/renegotiation (when UE moves or radio changes occasionally) via NAS also involve AS layer overhead, we no long pursue it.  Therefore, we prefer to focus on RAN level information alternatives, Alt1~Alt3.  For Alt1, considering the RSRP mesurement accuracy, the CE level based on measured RSRP value may change or fluctuate frequently even the UE is almost stationary. For example, if the RSRP is around the RSRP threshold, it’s easy to occur CE level fluctuation. Moreover, according to previous discussion on Msg3/Msg5 CQI reporting and also its RAN4 definition, we think Alt2, e.g., an estimated BLER for decoding NPDCCH considering a certain paging Rmax being above a certain percentage threshold, e.g. 1 or 10%, could be more stable for low mobility UE than Alt1, so we not prefer Alt1 and ok to further consider Alt2.  For Alt3, it’s already in eNB implementation and no need of specification work. E.g, if we go for this Alt3, we don’t need to specifiy how to determine the CE level. We mainly need to define the procedure for delivering the CE level evaluated by eNB to the UE.  In a summary, we prefer Alt2 and Alt3 for further discussion. |
| Nokia | As first step, how the network intend to divide the paging across carriers based on repetition level needs to be determined. Once the network determines the network can configure the maximum repetition for each of non-anchor carrier based on this distribution. As simple configuration network may map the Rmax level of paging carriers with 3 different values which corresponds to the Rmax of RAR search space so that it is possible to map to the CEL to paging carrier. But the configuration need not be restricted like this.  As second step the UE should know where the network will send the paging after connection release in case of paging carriers configured with different Rmax value. Network may configure specific carrier for this purpose or the number of repetitions. RAN2 can further discuss on these possible options.  This negotiated carrier or Rmax value for selection of paging carrier for paging monitoring is applicable only for last connected cell. The paging carrier selection after mobility from last connected cell needs to be determined in different way. This require further discussion within RAN2.  We think at high level following could be considered for RAN2 agreement :  **UE and ENB negotiate some parameters which will be used to determine the paging carrier to monitor after RRC connection release. FFS details.** |
| Ericsson | First we want to clarify that coverage is radio condition. Hence, there is no possibilty as such for negotoation between UE and MME/AMF via NAS. Coverage is based upon radio condition and determiend by radio measurements and interference (e.g number of users in cell (Quality RSRQ), inter-cell/intra/inter-frequency). Only eNB with help from UE measurements and other interference based measurements can judge coverage. Further eNB owns the resources (carriers) and it should basically determine based upon number of carriers available, prevaling radio condition/coverage, power boost applied or, UE RSRP/RSRQ and decide what is the best carrier where UE should monitor paging.  If there is flutuation or change in the coverage level based upon assigned carrier by eNB for paging monitoring. The UE may judge those changes based upon idle mode measurements:   * Based upon what Rmax (NPDCCH Repetition) has been configured and if UE based upon measurement judges higher Rmax value would be needed than configured. * an estimated BLER for decoding NPDCCH considering a certain paging Rmax being above a certain percentage threshold, e.g. 1 or 10%, similar to what is already done for Msg3 CQI reporting.   Further, NW may consider the Alt3 mentioend by ZTE.  What action should UE take if coverage detoriates should be discussed. It is clear it will incur massive signalling whether based upon Alt 4: TAU update or based upon just RAN level where UE is asked to report teh changes in it’s coverage level.  Hence, some pre-determined information can be provided by eNB on what to do if coverage detoriates. This would help paging to be deterministic; eNB knows how to page UE if it does not find UE in previously assigned carrier. |
| Qualcomm | We don’t necessarily see the difference between Alt1 and Alt2 in that they are both a metric the related to the radio condition. Either one of both can work. We understand NRSRP is a longer term metric i.e an averaged value of 2 or more samples where as BLER is a single message metric. Furthermore, Alt3 is closely related to Alt2.  Not clear what is meant by Alt4 apart from the case of coverage restriction i.e. if UE is configured with coverage restriction then both UE and NW knows up to what coverage level (NRSRP as per current spec) a UE can be reached. Therfore, we interpret Alt4 as a ’system level’ behaviour for paging carrier selection based on coverage level and this automatically implies it is based on NRSRP.  Therfore, we think NRSRP is a resonable metric to use for paging carrier selection. |

**Summary 1**:

5 companies responded. 3 companies (ZTE, Ericsson, Nokia) view that coverage can be based upon NPDCCH Repetitions (Rmax). One comany (Huawei) view is that it should be based between UE and Core Network negotiation. Another company (Qualcomm) view is that it should be based upon NRSRP (Similar to RACH procedure CE level RSRP threholds). 3 companies have clearly provided there view that MME should not be involved in coverage determination or negotiation. Two companies (Huawei, Nokia) expressed the view that the negotiated/assigned carrrier should be determined during the RRC connection and only be applicable in that cell (i.e. the last used/known cell).

**Proposal 1**: MME is not involved in coverage determination and coverage is radio condition which cannot be negotiated between UE and MME.

**Proposal 2**: The negotiated/assigned carrrier should be determined during the RRC connection and only be applicable in that cell.

**Proposal 3**: RAN2 to consider NPDCCH BLER target for certain Rmax and/or NRSRP threshold (for paging, not same as CE level threshold) for coverage determination.

## 2.2 DRX Information for Paging

There has been suggestion to make use of the DRX cycle that the UE is supposed to use for Paging carrier selection [1,2, 5, 6]. Considering an example; for a paging carrier supporting normal coverage level or power boosted carrier where the Rmax is configured with small *NumRepetitionPaging,* in such casethe UE with short UE specific DRX cycle can be configured or UE may select such carrier. Similarly, UEs that do not support short DRX cycle may be configured or UE may select the paging carrier supporting extended coverage level configured with large *NumRepetitionPaging*.

Further, observation has been provided that the benefits may be marginal for UE already in eDRX configuration which achieves the major power saving due to deep sleep for longer duration [4]. It has also been observed that paging carrier solely based upon DRX cycle may not be appropriate and Rmax or coverage level should be considered [2, 3].

Note: RAN2 have not yet discussed whether eNB will assign paging carrier or UE will select. This is not part of current email discussion. It is just to gather input on DRX usage for paging.

Companies are invited to provide their view on DRX Information for Paging; whether UE specific DRX information should/can be used or not. Further, can solely based upon DRX cycle the paging carrier be decided i.e

* whether DRX cycle is considered in addition to coverage level (Rmax) or
* can be considered indepenednt of Rmax

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| Company | Comments |
| Huawei, HiSilicon | We think UE specific DRX information can be used as it is known by both the eNB and the UE before paging.  The main benefit of DRX cycle based carrier seletion is to assign UE with short DRX cycle to a paging carrier with smaller Rmax to avoid CSS overlapping and improve paging latency. Thus we think DRX cycle based carrier selection is realted to coverage based carrier selection. |
| ZTE | We have opposite understanding about ”DRX cycle based carrier selection is realted to coverage based carrier selection”. We think carrier selection based on UE DRX cycle cannot work in some scenarios and CE Level-based paging carrier selection can achieve same results as carrier selection based on UE DRX cycle.  As mentioned in [R2-2009059](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009059.zip" \o "https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009059.zip)[2], if the UE with short UE specific DRX cycle locates in the good coverage and is with small CE level, it can naturally select a carrier for the good CE level, e.g., with small *NumRepetitionPaging*. This is same as the expectation from the scheme based on carrier specific DRX cycle configuration. However, if the UE with short UE specific DRX cycle accidentally locates in bad coverage, it will be incorrect for the UE to still select the carrier that is matched its DRX cycle and with smaller Rmax. The UE would not work normally on this carrier. For such case, it’s more suitable to let UE still perform CEL-based paging carrier selection, e.g., ignoring its short DRX cycle.  Therefore, we think CE level based paging carrier selection is enough and no need to consider separately carrier selection based on DRX cycle. |
| Nokia | Assigning carrier having lesser repetitions which allows shorter UE specific DRX cycle without search space overlap should be possible. But in case if the UE moves to extended coverage within same cell, how should it modify the paging monitoring to different carrier with higher DRX cycle needs to be discussed further. For correct UE behaviour, these UE may need to renegotiate the DRX cycle in case if the coverage level prior to paging monitoring does not qualify the UE specific DRX cycle, it need select carrier having supports shortest DRX cycle closer to its UE specific DRX cycle.  In our view :  As of now Rmax is configurable for each paging carrier. Configuration of DRX cycle and NB value for each paging carrier can be supported optionally independent of Rmax. |
| Ericsson | We need to first prioritize solution based upon Rmax/Coverage. Once it is in place, other criterias such as DRX and nB per carrier configuration can also be discussed. |
| Qualcomm | We think DRX based paging carrier selection can be useful and it can be used own it’s own or combined with coverage based paging carrier selection. |

**Summary 2**:

5 companies responded. 3 companies (Huawei, Nokia, Qualcomm) think DRX cycle should be considered. Out of these 3 companies, 2 companies clearly indicate that DRX cylce can be configured independetly of Rmax.

One company view (Ericsson) is that first Rmax based solution should be prioritized and later other criterias such as DRX and nB per carrier configuration can also be discussed. Another company view (ZTE) is that Rmax based solution is adequate and no further need of DRX based solution.

One company mentions that further negotiation between UE and MME may be needed. Another company view is that eNB is always aware of DRX cylce that UE is using.

The end to end solution for DRX cylce is missing and further discussion would be required based upon more detailed contributions.

**Proposal 4**: RAN2 to further discuss DRX cylce for paging carrier selection in next meeting via contributions

# Conclusion

**Proposal 1**: MME is not involved in coverage determination and coverage is radio condition which cannot be negotiated between UE and MME.

**Proposal 2**: The negotiated/assigned carrrier should be determined during the RRC connection and only be applicable in that cell.

**Proposal 3**: RAN2 to consider NPDCCH BLER target for certain Rmax and/or NRSRP threshold (for paging, not same as CE level threshold) for coverage determination.

**Proposal 4**: RAN2 to further discuss DRX cylce for paging carrier selection in next meeting via contributions

# References

[1] [R2-2010470](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2010470.zip) Carrier selection enhancement MediaTek Inc.

[2] [R2-2009059](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009059.zip) Further consideration on multi carriers configuration and selection ZTE Corporation, Sanechips

[3] [R2-2009147](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009147.zip) Discussion on enhanced paging carrier selection and multi carrier configuration Spreadtrum Communications

[4] [R2-2009269](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009269.zip) Analysis on carrier selection options for NB-IoT Nokia, Nokia Shanghai Bell

[5] [R2-2009732](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009732.zip) Paging carrier selection based on CEL and on DRX Huawei, HiSilicon discussion

[6] [R2-2009790](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009790.zip) Support for NB-IoT carrier selection based on the coverage level Qualcomm Incorporated

[7] [R2-2009180](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Docs/R2-2009180.zip) NB-IoT carrier selection and configuration based on coverage level Ericsson