**3GPP TSG-RAN WG2 Meeting #113e R2-20xxxxx**

**Electronic Meeting, 25th Jan – 5th Feb 2021**

**Source: ZTE Corporation**

**Title: Email discussion 155 – RRM Relaxations**

**Agenda item:**  **x.x.x**

**Document for:** **Discussion and Decision**

# Background

After RAN2\_112e meeting, the following email discussion was agreed to progress the discussion on RRM relaxation solutions for Redcap UE:

* **[Post112-e][155][REDCAP] RRM relaxations (ZTE)**

 Scope: Progress on solutions for RRM relaxations

 Intended outcome: email discussion report

 Deadline: Long

Rapporteur would like to have following schedule for this email discussion to have enough time for preparing the summary report.

* Phase 1 (2021-01-06): Companies are invited to provide inputs and comments to questions.
* Phase 2 (2021-01-12): Rapporteur will provide draft summary with proposals, companies are invited to provide comments to the summary proposals.

# Contact information

|  |  |
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# Background—Rel-16 RRM relaxation mechanism

## UE identification criteria (or triggering condition)

For Rel-16 RRM relaxation in power saving WID, on whether a UE can perform relaxed measurement, the spec has defined two triggering evaluation criteria: Low-mobility and not-at-cell-edge, the corresponding evaluation formulas are given as below (see details in TS 38.304). In addition, network can configure the triggering criteria independently (i.e. either low-mobility, or not-at-cell-edge, or both).

* **Low-mobility criterion:**

- (SrxlevRef – Srxlev) < SSearchDeltaP for a period of TSearchDeltaP;

Note: based on the fluctuation of serving cell’s RSRP.

* **Not-at-cell-edge criterion:**

- Srxlev > SSearchThresholdP, and,

- Squal > SSearchThresholdQ, if SSearchThresholdQ is configured,

Note: based on comparison between serving cell’s RSRP (or RSRP&RSRQ) with absolute threshold(s).

## Measurement relaxation methods

Basically, Rel-16 spec has defined two methods for measurement relaxation:

* Method 1: Relax measurements with longer intervals (scaling factor), defined in TS 38.133.
* Method 2: Stop measurements for up to 1 hour.

UE applies different relaxation methods based on low-mobility, not-at-cell-edge evaluation and cell reselection priority of target inter-freq, inter-RAT frequencies. The application of method 1&2 is briefly summarized in below table (see details in TS 38.304):

(Condition 1: serving cell fulfils Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ)

Table 3.2-1 Rel-16 RRM relaxation mechanism

|  |  |  |
| --- | --- | --- |
|  | Single condition is configured | Both triggering conditions are configured |
| low mobility | not-at-cell-edge | either one of conditions is met | both are met |
| Intra-freq measurement  |  Method 1 | Method 1 | Method 1 | Method 2 |
| equal or low priority of inter-freq, inter-RAT measurements |  Method 1 | Method 1 | Method 1 | Method 2 |
| high priority of inter-freq, inter-RAT measurements  | * Condition 1 is met:

>> Method 2 or no relaxing* otherwise:

>> Method 1  | * Condition 1 is met:

>> no relaxing* otherwise:

>> Method 1  | * Condition 1 is met:

>> no relaxing* otherwise:

>> Method 1  | Method 2 |

# Skeleton of RRM relaxation for Redcap

Regarding RRM relaxation for Redcap UEs, rapporteur lists all scenarios in below Table, and the progress of RAN2 discussion is also provided in the table.

Note: the terms “fixed or immobile UEs” and “slightly moving UEs” are excerpted from endorsed TP[24]

Table 4-1 RRM relaxation scenarios for Redcap UEs

|  |
| --- |
| **RRM relaxation scenarios for Redcap UEs**  |
|  | Fixed or immobile UEs | Slightly moving UEs |
| RRC\_IDLE and RRC\_INACTIVE | Neighbor cell measurement | Take Rel-16 RRM relaxation as a baseline, FFS on enhancement | Take Rel-16 RRM relaxation as a baseline, FFS on enhancement |
| Serving cell measurement | FFS | FFS |
| RRC\_CONNECTED | Neighbor cell measurement | Will be studied, FFS on solutions | Will be studied, FFS on solutions |
| Serving cell measurement | FFS | FFS |

In the summary [23] of offline #114 in last RAN2 meeting, there was a tentative proposal related to the number of relaxation levels for Redcap UEs:

**Proposal 7 (14/18): RAN2 will study ways and feasibility of supporting different relaxation levels for fixed UEs and slightly moving UEs.**

Rapporteur understands the original motivation of this proposal is that, for Redcap UEs, RAN2 will study/define different triggering criteria and relaxation mechanisms for “**fixed UEs**” and “**slightly moving UEs**”. However, during the last round of offline discussion, some companies showed different understandings of this proposal.

In this document, instead of discussing this high level question (e.g. number of relaxation levels), rapporteur would suggest we directly discuss the potential solutions for each scenario (i.e. focus on those FFS points in Table 4-1), so questions are provided for each scenario separately. Company who prefers unified solution can keep it in mind when providing the inputs. In addition, rapporteur will try to summarize the inputs to find if we can get unified solution in the end.

The previous RAN2 agreements are given as below for your reference.

RAN2\_112e Agreements:

1. The target REDCAP UE, considering mobility, is not limited to a fixed UE, but can also experience some low mobility, and this, during some “stationary” periods of time.
2. The RRM relaxation of REDCAP UEs is triggered based on measurements, as a baseline. Other triggering conditions for the “level-1” (still device at fixed location) UEs are not excluded, e.g. the possibility to signal their stationary property explicitly.
3. R16 NR RRM relaxation procedures are taken as a baseline to study further enhancements of neighbor cells RRM relaxation for REDCAP UEs in RRC IDLE/INACTIVE.
4. Relaxation of neighbor cells RRM measurements in RRC\_CONNECTED will be studied in this SI/WI

# General principles

As mentioned in section 3, the Rel-16 RRM relaxation mechanism mainly includes two parts:

* Part 1: UE identification criteria/triggering conditions (e.g. low mobility, not-at-cell-edge)
	+ Identify in which cases the UE can perform relaxed measurements;
* Part 2: Measurement relaxation methods (e.g. longer interval, stop measurements)
	+ Identify the detail methods for intra-freq, inter-freq, inter-RAT measurement relaxation.

So regarding RRM relaxation for Redcap UEs, the discussion is organized into two parts:

* Part 1: UE identification criteria/triggering conditions
* Part 2: Measurement relaxation methods.

Based on the experience of Rel-16 power saving discussion, RAN2 is mainly responsible for determining the solutions for UE identification criterion and inform RAN4 about the decision.

While for measurement relaxation methods, RAN2 can discuss potential and preferable solutions, but from RAN2’s point of view, it is hard to evaluate the power saving gain and risk of performance impact for each solution. So in any case, RAN4 should be consulted before making the final decision. Thus for providing guidance to future discussion, principle 1 is given as below:

**Principle 1: RAN2 is mainly responsible for discussing and deciding solutions for Part 1 (UE identification criteria). For Part 2 (measurement relaxation methods), RAN2 can discuss preferable solutions, but RAN4 should be consulted before making the final decision.**

**Q0-1: Do companies agree with above Principle 1 (if no, please provide your comments)?**

|  |  |  |
| --- | --- | --- |
| Company  | Agree/ Disagree | Comments |
| Nokia, Nokia Shanghai Bell | Disagree | Part 1: It has been agreed that the RRM relaxation of REDCAP UEs is triggered based on measurements which is clearly RAN2 responsibility area and we think that RAN2 should focus on that. Other “UE identification criteria” can be downprioritized. Therefore, wording of the proposal could something like this: “RAN2 is mainly responsible for discussing and deciding solutions for triggering RRM measurement relaxation.”Agree with part 2. |
| Ericsson | Agree, but | We can discuss the whole framework for relaxation in RAN2 but need to consult RAN4 for performance impact of the potential solutions.  |
| OPPO | Agree |  |
| CATT | Agree |  |
| Huawei, HiSilicon | Agree | We understand it is a general principle including SI and WI phases. For the detailed solution for RRM measurement relaxation, both power saving gain and performance should be considered, it is reasonable to consider RAN4 inputs. |
| Qualcomm | Agree |  |
| Sharp | Agree |  |
| Xiaomi | Agree |  |
| Intel | Agree |  |
| Futurewei | Agree |  |
| Samsung | Agree |  |
| LG | Agree | Generally same understanding with the proposal. Regarding the UE identification when to relax the measurements, we already categorized the stationary UEs into four cases in the previous email discussion. (i.e. truly stationary, truly stationary but rotating, temporarily stationary, moves around with low mobility). So we can discuss how to relax the measurement in each case, but does rapporteur has different understanding on UE identification? |

Another aspect is about the control of enabling RRM relaxation mechanism, in Rel-16 power saving, RRM relaxation is only supported for neighbour cell measurement in RRC\_IDLE/INACTIVE, and network can decide whether to enable the function by the presence/absence of the “*lowMobilityEvaluation*” and “*cellEdgeEvaluation*” configuration in system information.

Regarding RRM relaxation for Redcap UEs, rapporteur understands the same principle can also be applied, that whether to enable/disable the RRM relaxation function is within network’s control, which means we will not consider UE autonomously performing measurement relaxation without network awareness. For instance, network may want to disable RRM relaxation function during the period of deployment change, or load balancing.

**Principle 2: Irrespective of RRC state, whether to enable/disable RRM relaxation function for Redcap UEs is within network’s control.**

**Q0-2: Do companies agree with above Principle 2 (if no, please provide your comments)?**

|  |  |  |
| --- | --- | --- |
| Company  | Agree/ Disagree | Comments |
| Nokia, Nokia Shanghai Bell | Agree |  |
| Ericsson | Agree |  |
| OPPO | Agree |  |
| CATT | Agree |  |
| Huawei, HiSilicon | Agree | Network’s control is preferred for RRC\_idle/inactive and RRC\_connected state since it impacts network performance. Especially for RRC\_connected, the ongoing service is critical and network’s control is necessary, not only enabling/disabling of the RRM measurement relaxation, but also being aware of whether relaxed measurement is performed by the UE or not so that the network can adjust some policy of configuration to avoid degrading performance. |
| Qualcomm | Agree |  |
| Sharp | Agree |  |
| Xiaomi | Agree |  |
| Intel | Agree |  |
| Futurewei | Agree |  |
| Samsung | Agree | We agree with Principle 2. The details about how NW controls/configures (e.g., presence/absence of the “*lowMobilityEvaluation*” and “*cellEdgeEvaluation*”) can be discussed later. |
| LG | Agree | We would like to clarify what ‘within network control’ means in RRC\_IDLE/INACTIVE. Does it just mean, as it is in R16, the network broadcasts the configuration and UE performs measurement relaxation if condition is satisfied? We are afraid if the ‘network control’ includes indication from the UEs. |

# Neighbour cell RRM relaxation in RRC\_IDLE/INACTIVE

After RAN2\_112e meeting, RAN2 agreed to take Rel-16 RRM relaxation mechanism as a baseline for Redcap UEs in RRC\_IDLE/INACTIVE, and enhancements can be further studied.

1. R16 NR RRM relaxation procedures are taken as a baseline to study further enhancements of neighbor cells RRM relaxation for REDCAP UEs in RRC IDLE/INACTIVE.

As mentioned before, the Rel-16 NR RRM relaxation mechanism includes two steps:

* Step 1: Identify whether UE can perform RRM relaxation, by evaluating two criteria:
	+ low mobility criterion;
	+ not-at-cell-edge criterion;
* Step 2: Perform relaxed RRM measurement for intra-freq, inter-freq, inter-RAT measurements accordingly.

Based on company contributions, different enhancement solutions were proposed for both steps. So we can discuss them separately:

* **Part 1:** Applicability and enhancement to UE identification criteria (e.g. “low mobility”, “not-at-cell-edge” criteria):
* **Part 2:** Applicability and enhancement to measurement relaxation methods.

## UE identification criteria

* **Applicability of Rel-16 UE identification criteria**

In this section, we first discuss the applicability of Rel-16 UE identification criteria for Redcap UEs. As mentioned in section 3.1, in Rel-16, network can enable “low mobility criterion” and “not-at-cell-edge criterion” independently (e.g. only low mobility, only not-at-cell-edge, or both).

For Redcap UEs, according to SID and previous RAN2 agreements, RRM relaxation can be considered for both fixed UEs and slightly moving UEs. Generally, both of them belong to “low mobility” case. So different from Rel-16 non-Redcap UEs, it is straightforward that Redcap UEs who can perform RRM relaxation must fulfill “low mobility” criterion. So rapporteur thinks there is no need to consider case of which “only not-at-cell-edge” is configured.

More specifically, for Redcap neighbour cell RRM relaxation in RRC\_IDLE/INACTIVE, based on Rel-16 mechanism, we can narrow-down the cases into followings:

* Case 1: only “low mobility” criterion is configured (i.e. irrespective of UE’s location)
* Case 2: both “low mobility” and “not-at-cell-edge” criteria are configured (i.e. differentiate “low mobility + cell center” and “low mobility + cell edge” UEs);

**Q1: For Redcap neighbour cell RRM relaxation in RRC\_IDLE/INACTIVE, only above two Cases from Rel-16 mechanism need to be considered?**

|  |  |  |
| --- | --- | --- |
| Company  | Agree/ Disagree | Comments |
| Nokia, Nokia Shanghai Bell | Disagree | We think that also “not-att-cell-edge” should be possible to configure separately as in REL-16.  |
| Ericsson | Disagree | There are also RedCap UEs in mobility, thus all of the existing criteria should be configurable, including “not-at-cell-edge”. |
| OPPO | Agree | Based on the SID, we only need to consider RRM relaxation for “stationary devices”. |
| CATT | Disagree (too early at this stage) | We agreed: “R16 NR RRM relaxation procedures are taken as a baseline to study further enhancements”. We understand this agreement as the possibility to add more relaxation criteria to existing legacy ones. Not to remove some for Redcap UEs. The only case where we could envision to not use some legacy criteria could be in the case of still device at fixed location where the UEs explicitly signal their stationary property. We agreed to not exclude this possibility, but we need to get into further details of this usecase.  |
| Huawei, HiSilicon | Agree | For REDCAP UEs, we could focus on low mobility case. |
| Qualcomm | Disagree | Our view is that in R17 network may signal any combination of the following three configurations for RRM relaxation:* R17 RRM relaxation for low mobility for RedCap “stationary” UEs;
* R16 RRM relaxation for low mobility for non-RedCap UEs;
* R16 RRM relaxation for not-at-cell-edge for any UEs (i.e. both RedCap and non-RedCap).

If a RedCap UE does not meet the R17 relaxation criterion for “stationarity”, it should still be allowed to check if R16 low mobility and/or not-at-cell-edge criteria apply. |
| Sharp | Disagree | It is too early to exclude the “only not-at-cell-edge” case. |
| Xiaomi | Agree | We should focus on low mobility case. |
| Intel | Disagree | Agree with others, do not see the problem to apply R16 power saving solutions for RedCap UEs.  |
| Futurewei | Disagree | Agree with comments from Nokia and Qualcomm. |
| Samsung | Disagree | We assume NW can configure RedCap relaxation separately with Rel.16 relaxation. Assume "only not-at-cell-edge” is configured for Rel.16. Then, different relaxation methods can be performed for each of following cases:Case 1) "not-at-cell-edge" is fulfilled & RedCap relaxation is fulfilledCase 2) "not-at-cell-edge" is fulfilled & RedCap relaxation is not fulfilledCase 3) "not-at-cell-edge" is not fulfilled & RedCap relaxation is fulfilled Case 4) "not-at-cell-edge" is not fulfilled & RedCap relaxation is not fulfilledAs rapporteur mentioned in Principle 1, RAN2 needs to discuss triggering condition for RedCap relaxation. Then RAN4 will determine relaxation methods for 4 cases.  |
| LG | Disagree | Similar understanding with preceding comments, we should focus on only stationary UE case.  |

* **Enhancement to Rel-16 UE identification criteria**

Regarding enhancement solutions to UE identification criteria for Redcap UEs, based on company contributions and online/offline comments, following enhancements have been proposed:

* Enhancement 1: Introduce additional SsearchDeltaP\_stationary threshold to support 2 level speed evaluation (i.e. stationary, low mobility); [13]
* Enhancement 2: Take into account of beam switching in low mobility evaluation; [13][20]
* Enhancement 3: UE determines its stationary property based on subscription information (e.g. USIM);
* Enhancement 4: Introduce an additional SsearchDeltaP\_correction threshold and configure the UE to use it if only it detects that it observes higher received signal power variation that do not violate stationarity i.e., rotating around itself, dynamically changing multipaths. [19]
* Enhancement 5: Introduce additional TSearchDeltaP\_stationary to support 2-level stationarity (i.e. fixed location vs low mobility);
* Other?

Enhancement 1&2 are optimization of Rel-16 low mobility criterion. While Enhancement 3 is based on UE’s subscription information instead of measurement results of serving cell.

Companies are invited to show your views on the proposed enhancement solutions.

Note: This is try to collect potential preferable enhancements that can be captured in TR. Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

**Q2: Companies are invited to provide your preference to the enhancement solutions of UE identification criteria for neighbour cell RRM relaxation in RRC\_IDLE/INACTIVE?**

|  |  |  |
| --- | --- | --- |
| Company  | Preferred enhancement(s)  | Comments |
| Nokia, Nokia Shanghai Bell | 4 | We think that any enhancements should be provide adequate gain and argumentation is needed for proving why REL16 mechanism is not sufficient. R16 mechanism can be used to relax as much as suggested by R16 mechanism without any improvement. The point of the discussing new methodology is to enable new relaxation, such as stopping measurement for a longer period. We can do that because UEs are stationary instead of low mobility. Detecting stationarity is different then detecting low mobility.Sometimes low signal variation means UE is moving and sometimes it means that a stationary device is rotating around itself. We need techniques to solve problem of differentiating which signal variation means UE is not stationary and which means UE is stationary moving around itself. In order to solve this problem we need to add extra information to the system, as such what kind of signal variation means UE is still stationary. This can be cell specific and should be communicated to the UE. Also multiple parameters needs to specify different variation values as each situation may result in different variation and a single cell wide value will not be sufficient. Examples of this will be, UE position related variation, line of sight related variation and UE antenna configuration related variation. |
| Ericsson | None at the moment | Unless significant gains (compared to NR Rel-16) can be demonstrated with any of the mentioned enhancements. We are open to capture any evaluations in the TR. |
| OPPO | Enhancement 2 | For enhancement 2, in the multi-beam scenarial, we think it would make sense to relax measurement on some beams in the case when UE is fixed at a certain beam. The RRM relaxation criterion and the method can be further studied.For enhancement 1, considering that multiple relaxation levels would increase the UE complexity when performing criteria checking, which will cause more power consumption, we prefer a unified relaxation scheme for low-mobility UEs and stationary UEs.For enhancement 3, stationary property based on subscription information could only apply to a limited case, i.e. stationary UEs, but could not be used for low mobility UEs.  |
| CATT | 2 & 3 | Enhancements 2 & 3 should be considered as they bring new and non-overlapping approaches to legacy. Especially 3 which can be very useful in reducing dramatically the amount of measurements, and should be appropriate for the level-1 stationary UEs (still devices at fixed location).  |
| Huawei, HiSilicon | 1 & 2 with comments | Supporting 2 level speed evaluation enables to design different measurement relaxation level for different mobility scenarios, which benefits the power saving. However, it is not enough to evaluate UE’s mobility scenario just based cell level measurement results, especially for the “stationary” case. For UE moves among beams, the UE may be considered as stationary when the cell quality does not change. However, it is possible that UE changes the moving direction or moves out the cell coverage and then cell reselection will not be triggered in time. So, beam level measurement results should be involved to explicitly identify the stationary criterion. |
| Qualcomm | 3; otherwise, 1 and 5.FFS 2. | We think #3 is useful to have for fixed-locations UEs, because it can enable network to configure more power-efficient RRM in RRC Connected. If #3 is not supported, we are fine with #1 and #5 as an enhancement for fixed-location UEs. |
| Sharp | 1  | To support the stationary use case some new threshold(s) may be needed. We are also open to other solutions. |
| Xiaomi | 1 | For 1, introducing a more restricted threshold to support 2 level speed evaluation (i.e. stationary, low mobility) seems to be a simple and natural way.For 2, we understand the intension is to relax measurement on some beams, but we are not sure of the gain.For 3, it seems that subscription information is coupled with UE mobility status which results only limited use cases and are not desirable. |
| Intel | 1&2&3 | 1 and 2 can work together, i.e. to consider two level mobility and taking into account the beam switching. 3 is useful for UEs with fixed location. The UE does not need to do measurement at all.  |
| Futurewei | 1/2/5, 3 | #1/2/5 can be used for both low mobility UEs and stationary UEs. The issues are accuracy and complexity.#3 can be used only for UEs that are permanently stationary, hence limiting the usage of the enhancement.  |
| Samsung | 1 or/and 5  | Currently, we prefer simple optimization like 1 or/and 5 based on the previous agreement: "*R16 NR RRM relaxation procedures are taken as a baseline to study further enhancements of neighbor cells RRM relaxation for REDCAP UEs in RRC IDLE/INACTIVE.*" |
| LG | Enhancement 1, but | As we could not spend enough time to discuss benefits of each solution, we can just introduce basic enhancements at this time. However, as Ericsson commented, if some benefits are seen, any proposed enhancements until the next meeting can be included in the TR if any benefits are expected. |

## Enhancement to measurement relaxation methods

Based on contributions, following enhancements have been proposed by companies.

* Enhancement 1: UE can stop measurements on neighbour cells for T (T>>1) hours; [17][18]
* Enhancement 2: Enabling further relaxation via reducing the number of monitored RS; [15][20]
* Enhancement 3: UE only perform measurements on a number of dedicated intra-freq, inter-freq cells; [18]
* Enhancement 4: Minimize the number of measured frequencies; [21]
* Other?

Note: This is try to collect potential preferable enhancements that can be captured in TR. RAN4 will be consulted before making the final decision. Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

**Q3: Companies are invited to provide your preference to the enhancement solutions of measurement relaxation method for neighbour cell RRM relaxation in RRC\_IDLE/INACTIVE?**

|  |  |  |
| --- | --- | --- |
| Company  | Preferred enhancement(s)  | Comments |
| Nokia, Nokia Shanghai Bell |  | We think that any enhancements should provide adequate gain and argumentation is needed for proving why REL16 mechanism is not sufficient. |
| Ericsson | None at the moment | Unless significant gains (compared to NR Rel-16) can be demonstrated with any of the mentioned enhancements. We are open to capture any evaluations in the TR. |
| OPPO | Enhancement 1& 2 | For enhancement 1, we could consider specifying RRM relaxation with a different measurement interval for stationary RedCap UEs from that for non-RedCap UEs. For enhancement 2, reducing the number of RSs for a UE fixed at a certain beam would be beneficial for power saving. |
| CATT | Stage 3 | Same view as Ericsson: we think we can capture all these various relaxation options but in the end RAN4 should decide and this, during the WI phase. |
| Huawei, HiSilicon | 1 and 2 | For 1, according to Rel-16 relaxation method, when low mobility criteria fulfilled, RedCap UE could perform RRM measurement relaxation by using longer measurement interval, but for stationary UEs, it is possible that RedCap UE cannot find a better cell at all. Hence, at least for stationary UEs, of which RSRP do not change frequently, measurements can be stopped for a period.For 2, When UE is in a certain coverage of a specific beam, UE only needs to measure the related beams for this certain location to save power. The unnecessary SSB to be measured can be avoided and the time period of measurement can be reduced. |
| Qualcomm | 1 | We think #1 can be studied. #2, 3 and 4 can already be done by UE implementation. |
| Sharp | 1 | The UEs with different mobility level may need different T. |
| Xiaomi | Stage 3 | 1 can be considered. But how to perform relaxation should be finally decided in RAN4. |
| Intel | 1  | #1 is at least useful to reduce power consumption for UEs with fixed location. Other solutions can be evaluated in RAN4.  |
| Futurewei | 1 | But open to other enhancements. |
| Samsung |  | As Ericsson and CATT mention, we are also fine to include all potential solutions in TR, but decision needs to be made by RAN4. |
| LG | 3 and 4 | We defined four stationary UE types, so we do not think different measurement relaxation method is needed for each type of UE. In order to reduce the power consumption as much as possible, the UE should perform measurements on only necessary frequencies. For example, stationary UEs do not need to perform measurement on all the frequencies broadcast, and only minimum number of frequencies (e.g. one or two) might be enough. For temporarily stationary UEs, while it is stationary, number of frequencies to measure should be minimized until it becomes mobile. |

# Neighbour cell RRM relaxation in RRC\_CONNECTED

Neighbour cell RRM relaxation in RRC\_CONNECTED is not supported in Rel-16. However, considering Redcap stationary UEs may not have handover requirement, thus RAN2 has agreed to study this scenario in this SI/WI. As indicated in Table 4-1, for neighbour cell measurements relaxation in RRC\_CONNECTED mode, following scenarios need to be discussed:

* Case 1: Fixed or immobile devices in RRC\_CONNECTED;
* Case 2: Slightly moving devices in RRC\_CONNECTED.

Companies are invited to show your preference that in which cases (e.g. Case 1~2) RRM relaxation can be performed (e.g. without significant performance impact).

**Q4: Companies are invited to provide your preference on support of neighbour cell RRM relaxation in different scenarios.**

|  |  |  |
| --- | --- | --- |
| Company | **RRC\_CONNECTED** | Comments |
| Fixed or immobile(Yes or No) | slightly moving(Yes or No) |
| Nokia, Nokia Shanghai Bell | Yes | Yes |  |
| Ericsson |  |  | We have not agreed or evaluated whether and how the mobility status can be distinguished. We assume that RedCap devices spend very little time in connected mode, see e.g. [17], and efforts in RAN2 should be spent on IDLE/INACTIVE enhancements, if any. |
| OPPO | Yes | Yes | Same as RRC IDLE and RRC INACTIVE, RRM relaxation should be considered for both UE mobility states in RRC CONNECTED. |
| CATT | Yes | No | We have the same view as Ericsson that this optimization should take minimum efforts. |
| Huawei, HiSilicon | No with comments | No with comments | RRM in RRC\_CONNECTED has large impact on handover performance. RRM relaxation in RRC\_CONNECTED may degrade the network performance, e.g. too late handover. In addition, to optimize handover parameters, UE needs to send RLF report to network after handover failure. If this handover failure is caused by RRM relaxation, network may adjust handover parameters wrongly. Hence, RRM relaxation in RRC\_CONNECTED should strictly under network control, at least including * Network configures RRM relaxation parameters
* UE informs the network the relaxation criteria is fulfilled to assist network to further decide whether to enable UE RRM relaxation

If neighbour cell RRM relaxation in RRC\_CONNECTED is to be supported, the principles above should be captured in the TR and fulfilled when design the solution to avoid potential negative impact on the network performance. |
| Qualcomm | yes | yes |  |
| Sharp | Yes | Yes |  |
| Xiaomi | - | - | RRM relaxation in RRC\_CONNECTED can be considered with low priority. |
| Intel | Yes | Yes | It can be controlled by the network.  |
| Futurewei |  |  | RAN2 should prioritize RRM relaxation in RRC\_ IDLE/INACTIVE over in RRC\_CONNECTED. |
| Samsung | Yes | Yes | We also have concern that RRM relaxation in RRC\_CONNECTED will be time-consuming work. However, this issue can be down-prioritized in the future if needed. Therefore, we believe RAN2 doesn't have to down-prioritize it right now. |
| LG | Yes | Yes | RRC\_IDLE/INACTIVE should be prioritized, but connected mode enhancements should be studied together. |

In [17], it is observed that it is unlikely Redcap devices stay for long periods of time in RRC\_CONNECTED, and RRC\_CONNECTED power consumption may already be reduced significantly through other means, e.g., lower supported bandwidth, so we should focus on RRM relaxation in RRC\_IDLE/INACTIVE states. Also in [], it is proposed to consider RRC\_CONNECTED RRM relaxation as low priority because it can yield power saving gain with risk of degrade network performance.

Thus companies are invited to show your views on whether RRM relaxation in RRC\_CONNECTED can be considered as low priority.

**Q5: Compare to RRC\_IDLE/INACTIVE, do companies agree that RRM relaxation in RRC\_CONNECTED can be considered with low priority?**

|  |  |  |
| --- | --- | --- |
| Company  | Agree/ Disagree | Comments |
| Nokia | Disagree | We think that not much needs to be done for REL16 IDLE/INACTIVE measurement relaxation. Some of the use cases defined in the SID may require long CONNECTED mode sessions e.g. video surveillance. Therefore we think that focus should be more on CONNECTED mode optimizations. |
| Ericsson | Agree | We assume RedCap devices are in IDLE/INACTIVE for a large portion of the time, thus power saving in IDLE/INACTIVE should be prioritized. |
| OPPO | Disagree | Among the three use cases for RedCap, IWSN is likely to stay in RRC IDLE or RRC INACTIVE for most of the time, but for video surveillance and wearables, the situation may be different. For video surveillance and wearables in RRC CONNECTED with low mobility, RRM relaxation would also play an important role for UE’s power saving.  |
| CATT | Agree | We share Ericsson’s view. |
| Huawei, HiSilicon | Agree | There is a risk of degrading performance. |
| Qualcomm | Disagree | We share similar view with OPPO. Voice call on a wearable device (e.g. smart watch) is a good example in which a low-mobility RedCap UE may stay in RRC Connected for an extended period of time. |
| Sharp | Disagree | Share the same view with OPPO and QC. |
| Xiaomi | Agree | We share Ericsson’s view. |
| Intel  | Disagree | Share the same view with OPPO and QC.  |
| Futurewei | Agree | Agree with Ericsson. |
| Samsung | Disagree | Refer to the answer of Q4. |
| LG | Agree | We do not want to preclude the RRC\_CONNECTED, but is lower priority than RRC\_IDLE/INACTIVE. |

## UE identification criteria

Based on company contributions and online/offline comments, following solutions have been proposed:

* Solution 1: UE reports “stationary” property to network in Msg5; [2]
* Solution 2: Network provides (e.g. low mobility, not-at-cell-edge) evaluation parameters to UE via dedicated signalling; [15]
* Solution 3: AMF sends “stationary” indication to gNB (based on UE subscription); [17]
* Solution 4: UE reports “stationary” in UE Assistance Information to network;
* Other?

Companies are invited to show your views on the solutions.

Note: This is try to collect potential preferable solutions that can be captured in TR. Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

**Q6: Companies are invited to show your preference to the solutions of UE identification criteria for neighbour cell RRM relaxation in RRC\_CONNECTED?**

(Can differentiate “fixed UEs” and “slightly moving UEs” if needed)

|  |  |  |
| --- | --- | --- |
| Company  | Preferred solution(s) | Comments |
| Nokia, Nokia Shanghai Bell |  | REL16 IDLE/INACTIVE RRM relaxation solution can be taken as baseline for CONNECTED mode as well. Beam domain for relaxation criteria could be studied further. |
| Ericsson | To be defined, if any | We should capture the evaluations related to the solutions and based on analysis of the different solutions do conclusions and recommendations.  |
| OPPO | Solution 2 | For neighbour cell RRM relaxation in RRC CONNECTED, we think Rel-16 neighbour cell RRM relaxation can be taken as baseline. In other words, RRM relaxation is triggered based on measurement. In addition to the SIB broadcasting approach in Rel-16, parameters for low-mobility/not-cell-edge criteria can also be configured via dedicated RRC signaling for UEs in RRC CONNECTED. |
| CATT | Min complexity and max commonality with idle/inactive. | Minimal complexity should be the key criterion for selecting among options. And we should also maximize the commonality with idle/inactive, i.e. reuse, whenever possible the same/similar criteria. For example if “stationary” property is explicit from UE (subscription information per enhancement#3 in Q2 for idle/inactive), it could be used in the same way in idle/inactive/connected and how it is signaled/reported to/by UE can be left to WI stage. Solutions 1&3 can be captured as possible options in the TR for implementing this approach. |
| Huawei, HiSilicon |  | For 1 and 3 with “stationary” property indication, the channel/link quality and measured RSRP/RSRQ may be changed even if the UE is purely stationary, In addition, static “stationary” property will limit RRM relaxation using scenarios to “UE always doesn’t move at all”, if RRM relaxation in RRC\_CONNECTED is agreed to support. This will be not beneficial for those RedCap UE which may keep stationary temporary, e.g. class time for children watch.2 with evaluation parameters are more reliable and the impacts on the system performance can be reduced. |
| Qualcomm | 1/3 & 4 | We have the same comment as CATT on #1/3.We also think it is useful for a UE to report to network that it is temporarily stationary, which would allow network to change its RRM measurement configuration to a more power-efficient one. |
| Sharp | 2 | Rel-16 RRM relaxation in IDLE/INACTIVE can be baseline. Then other enhancements are also can be studied. |
| Xiaomi | - | REL16 IDLE/INACTIVE RRM relaxation solution can be taken as baseline if we decide to introduce it. |
| Intel | 1/3&4 | These solutions are all possible to let the RAN know the RRM measurement of INACTIVE/CONNECTED UE can be further relaxed. But for IDLE mode UE, all of these solutions are not needed.  |
| Futurewei | None at the moment | Should RRM relaxation in RRC\_CONNECTED be supported in Rel-17, agree with CATT that commonality with RRC\_IDLE/INACTIVE and simplicity are desirable.  |
| Samsung | 2 | Even though RedCap UE is stationary, serving cell quality may drop due to environmental change (e.g., LOS blockage). In this scenario, UE with solution 1/3/4 still uses relaxed measurement for neighboring cells. Then, the UE cannot perform handover appropriately. However, solution 2 (i.e., Measurement-based triggering condition) can cope with this by cancelling relaxed measurement after detecting degradation of serving cell quality. |
| LG |  | We think different method from RRC\_IDLE/INACTIVE can be considered in RRC\_CONNECTED, as dedicated signaling can be used. Or we can consider to indicate the stationary status of the UE to the network upon access to the network so that the network refer the information to provide configuration to the UE. For example, if temporarily stationary UEs indicate to the network whether it is stationary or not, the network may provide appropriate measurement configuration to the UE. If it is stationary, then the UE does not need number of frequencies to measure. |

## Measurement relaxation methods

Regarding measurement relaxation methods, rapporteur understands Rel-16 IDLE/INACTIVE relaxation methods cannot be directly reused, because for RRM measurements in RRC\_CONNECTED mode, there is no *Sintrasearch*, *Snonintrasearch* thresholds, and there is no priority configured for measured target frequencies. In addition, the relaxed measurement requirements defined in TS 38.133 are not applicable to connected mode measurements.

Based on company contributions and online/offline comments, following solutions have been proposed so far:

* Solution 1: Ask RAN4 to define relaxed measurement intervals;
* Solution 2: Network does not configure RRM configuration for mobility purpose; [6]
* Solution 3: Perform measurement on single RS type (SSB or CSI-RS, not both) during relaxing period; [15]
* Other?

Companies are invited to show your views on the solutions.

Note: This is try to collect potential preferable solutions that can be captured in TR. RAN4 will be consulted before making the final decision. Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

**Q7: Companies are invited to show your preference to the solutions of RRM relaxation mechanism for neighbour cell RRM relaxation in RRC\_CONNECTED?**

(Can differentiate “fixed UEs” and “slightly moving UEs” if needed)

|  |  |  |
| --- | --- | --- |
| Company  | Preferred solution(s) | Comments |
| Nokia, Nokia Shanghai Bell |  | We think that RAN4 needs to be consulted, but it needs to be discussed in RAN how and whether RAN4 is included in the work item. |
| Ericsson | - | Similar to Q6 we need to see evaluations first to make a selection. We prefer solutions which are low complexity and show significant gain without negatively affecting the performance. RAN4 needs to be consulted in any final selection. |
| OPPO | Solution 3 | A UE in RRC CONNECTED performs SSB and CSI-RS measurements, if both are configured by the network. In the existing measurement procedure, UE starts (or stops)  neighbour cell measurements on both RS types at the same time, according to s-measure criteria. If measurement relaxation criteria is met, measurements on single RS type (SSB or CSI-RS) would achieve further UE power saving compared to measurements on both RS type2. The details can be further studied. |
| CATT | 1 | It is preferable that RAN4 is involved as early as possible to avoid the back and forth LSs and decisions adjustments we had R16 Power Saving WI on RRM relaxation discussions. |
| Huawei, HiSilicon |  | If RRM relaxation in RRC\_CONNECTED is agreed to be specified, further evaluation is needed on the power saving gains and RAN4 confirmation. For solution 2, we think it just works in some special cases, e.g. UE is at cell center and it is stationary. For the case of UE being stationary but at cell edge, UE may needs to handover to another cell due to bad link quality, so it needs some neighboring cell measurement but with relaxed measurement possibly. For the low mobility case, UE needs to measure some neighboring cells just in case possible handover. |
| Qualcomm | 1 | We think relaxation methods should be left to RAN4 to decide. |
| Sharp | 1 | RAN4 needs to be involved. And it is different from RRC\_IDLE/INACTIVE, the network may need more flexible control on the relaxed measurement interval for RRM relaxation in connected mode. |
| Xiaomi | 1 | How to perform relaxation should be finally decided in RAN4. |
| Intel | 1 | It should be decided by RAN4.  |
| Futurewei | None at the moment | But RAN2 is not the only group that should have a voice in this. At least RAN4 should be consulted first. |
| Samsung | 1 | We support solution 1, but RAN4 can also consider any other options (e.g., relaxed frequency) in addition to relaxed intervals.  |
| LG |  | As we commented in Q6, we do not want to use much signaling to use measurement relaxation in RRC\_CONNECTED, we think stationary status indication from the UE may be enough so that it is up to network implementation how to configure relaxed measurements to the UE. |

# Serving cell RRM relaxation

Serving cell RRM relaxation is not supported in Rel-16 due to the concern of performance impact. So far, RAN2 haven’t concluded whether to support serving cell RRM relaxation for Redcap UEs because of the different views from companies. In [9][15], it is observed that serving cell relaxation may lead to too late cell reselection(or handover), and considering RRM relaxation of neighbour cell is based on the results of serving cell, due to relaxed serving cell measurement, UE may continue relaxing neighbour cell measurement even if the relaxation criteria is not fulfilled any more, which leads to bad mobility performance. During email disc [16], some companies also commented there is limited power saving gain with serving cell measurement relaxation, as the UE has to monitor serving cell for paging reception, and by introducing eDRX, the measurement interval of serving cell is already relaxed. However, in [14], it is observed UE can achieve about 10% power saving gain if Redcap UEs to process SSBs in serving cell once per 5.12s (every four paging cycles). And in [13][14], it is observed that stationary UE may not moving, so there may be no bad impact to mobility performance.

In this section, rapporteur would suggest to first discuss the necessity of supporting serving cell measurement relaxation for Redcap UEs. As indicated in Table N, the following scenarios are involved:

* Case 1: Fixed or immobile devices in RRC\_IDLE and RRC\_INACTIVE;
* Case 2: Slightly moving devices in RRC\_IDLE and RRC\_INACTIVE;
* Case 3: Fixed or immobile devices in RRC\_CONNECTED;
* Case 4: Slightly moving devices in RRC\_CONNECTED.

Companies are invited to show your preference that in which cases (e.g. Case 1~4) serving cell RRM relaxation can be performed (e.g. consider power saving gain vs performance impact from RAN2 perspective).

**Q8: Companies are invited to show your preference on support of serving cell RRM relaxation in different scenarios.**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | **RRC\_IDLE/RRC\_INACTIVE** | **RRC\_CONNECTED** | Comments |
| Fixed or immobile(Yes or No) | slightly moving(Yes or No) | Fixed or immobile(Yes or No) | slightly moving(Yes or No) |
| Nokia, Nokia Shanghai Bell | No | No | No | No | Relaxing serving cell measurement will cause likely severe problems in CONNECTED mode like delayed HOs, radio link failures which should be avoided. Also for IDLE and INACTIVE mode it is beneficial that the UE is on the best cell when it starts the connection establishment, otherwise different problems may occur i.e. random access on the non-best cell causing interference or additional HOs after connection establishment etc  |
| Ericsson |  |  |  |  | RRC\_CONNECTED is being studied by RAN4 in Rel-17. The introduction text mentions multiple drawbacks already and without further evaluations for RedCap it is difficult to assess the different options.  |
| OPPO | No | No | No | No | We have strong concern on serving cell RRM relaxation considering that serving cell measurement relaxation may lead to too late cell reselection/handover and make the evaluation for neighbouring cell relaxation less stable. |
| CATT | FFS | No | No | No | We are OK to study further serving cell RRM relaxation of fixed UEs in Idle/Inactiveassuming the “stationary” property is explicit from UE (subscription information per enhancement#3 in Q2 for idle/inactive). But the key point is to assess the actual benefit considering the UE still needs to monitor paging. |
| Huawei, HiSilicon | No | No | No | No | There is a risk of degrading performance. |
| Qualcomm | No | No | No | No |  |
| Xiaomi | No | No | No | No |  |
| Intel | Yes | No | Yes | No | At least for stationary devices, it is reasonable to also relax measurement for serving cell since the UE is not moving. But would be ok to be further studied in RAN4.  |
| Futurewei | No | No | No | No |  |
| Samsung | No | No | No | No |  |
| LG |  |  |  |  | We are fine to study serving cell measurement relaxation, but evaluation by RAN4 should be done in advance.  |

If “serving cell RRM relaxation” is supported, then similar to neighbor cell measurement relaxation, we need to further discuss the triggering condition for serving cell RRM relaxation. As we can see, the Rel-16 low mobility criterion or not-at-cell-edge criterion are both evaluated based on the measurement results of serving cell, and serving cell RRM relaxation is not supported in Rel-16. Therefore, when the quality of serving cell fluctuates, the UE may evaluate the triggering criteria is not fulfilled immediately, and switches from “RRM relaxed mode” to “normal RRM mode”, this can avoid impact to cell-reselection performance.

For Redcap UEs, we need to consider whether it is still appropriate to use “serving cell measurement result” to define the triggering condition? For instance, the wearable device may evaluate itself to be in “stationary” state at night, but it may move at any time, thus if serving cell measurement is relaxed, then the UE switches from “RRM relaxed mode” to “normal RRM mode” may be delayed as well.

Based on the agreements made last meeting, RRM relaxation for Redcap UEs can be triggered based on measurements or UE property… etc. So companies are invited to show your views on how to define the triggering condition for serving cell RRM relaxation.

* Option 1: Serving cell relaxation is triggered based on the evaluation of serving cell measurement results;
* Option 2: Serving cell relaxation is triggered based on UE’s stationary property (e.g. derived from UE subscription information);
* Other?

Note: This is try to collect potential preferable solutions that can be captured in TR (if serving cell RRC relaxation is supported). Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

**Q9: If “serving cell RRM relaxation” is supported, which option do you prefer to define the triggering condition for serving cell RRM relaxation?**

|  |  |  |
| --- | --- | --- |
| Company  | Preferred option(Option 1, 2…) | Comments |
| Ericsson |  | We can wait for the simulations in PS WI and then discuss this again. Such features may add complexity so power saving gain needs to be significant. |
| OPPO | None | See our reply to Q8. |
| CATT | Option 2 | We think this is the least complex approach. |
| Huawei, HiSilicon |  | We need to be really careful on serving cell RRM relaxation, as the measurement results of serving cell is the basis for the neighbor cell measurement. |
| Intel  | Option 2 |  |
| LG | Option 1 | Regardless of how stationary UE is, serving cell measurement relaxation should be performed if the measured quality is stable and good enough. |

As mentioned in section 3.2, the Rel-16 measurement relaxation mainly includes two methods (e.g. longer interval, stop measurement for 1hour), so companies are invited to provide your preferred solution for serving cell measurement relaxation.

Note: This is try to collect potential preferable solutions that can be captured in TR (if serving cell RRC relaxation is supported). RAN4 will be consulted before making the final decision. Proponent of each solution are encouraged to provide the Pros and Cons and spec impact in your inputs.

In addition, as commented by companies during previous RAN2 meeting. For IDLE/INACTIVE Redcap UEs, the UE needs to monitor Paging message, thus typically, UE needs to wake up before paging occasion to detect/measure the best SSB beam for paging reception. So when providing serving cell measurement relaxation solution for IDLE/INACTIVE states UEs, please take this into consideration, and indicate whether it would need any change of paging monitoring behaviour.

**Q10: If answers “Yes” to any scenario in Q8, please provide your preferred solution for serving cell RRM relaxation. E.g. stop measurement, or increase measurement interval…etc.**

Note: When providing solutions, please also indicate whether it would need any change of basic IDLE/INACTIVE behaviour (e.g. paging monitoring).

|  |  |
| --- | --- |
| Company  | Preferred solution for serving cell measurement relaxation(Note: can differentiate Case 1~4 if needed) |
| CATT | Leave it to RAN4 |
| Intel | Leave it to RAN4.  |
|  |  |
|  |  |

# Other

Besides the previous questions, do companies identify any issue that needs discussion?

**Qn: Besides previous questions, any other issue that needs discussion?**

|  |  |
| --- | --- |
| Company  | Comments |
| Ericsson | It is difficult to do any recommendations for RRM relaxation without proper evaluations, i.e., including analysis of feasibility, benefit and complexity. Ideally these evaluations should be added to the TR and the recommendations would be made based on those. |
|  |  |
|  |  |

# Summary

To be provided later…

# Reference

RAN2\_111e

1. R2-2006607 Power saving enhancements for RedCap UEs Qualcomm Inc discussion Rel-17 FS\_NR\_redcap
2. R2-2006662 RRM relaxation for stationary devices Samsung discussion Rel-17 FS\_NR\_redcap
3. R2-2006693 RRM relaxation for power saving vivo, Guangdong Genius discussion Rel-17 FS\_NR\_redcap
4. R2-2006748 Use cases target to extend paging DRX cycle and relax measurements for stationary devices Intel Corporation discussion Rel-17 FS\_NR\_redcap
5. R2-2006788 Discussion on RRM relaxation OPPO discussion Rel-17 FS\_NR\_redcap
6. R2-2006902 Consideration on RRM relaxation for Redcap UE ZTE Corporation, Sanechips discussion Rel-17 FS\_NR\_redcap
7. R2-2006913 Reducing power consumption in RedCap devices Ericsson discussion FS\_NR\_redcap
8. R2-2007111 Impact of power-saving aspects on RedCap UEs Apple discussion Rel-17 FS\_NR\_redcap
9. R2-2007347 RRM measurement relaxation for REDCAP UE Huawei, HiSilicon discussion Rel-17 FS\_NR\_redcap
10. R2-2007471 RRM relaxation for stationary UE with reduced capability Lenovo, Motorola Mobility discussion Rel-17
11. R2-2007561 Power saving and battery lifetime enhancement for REDCAP UE Nokia, Nokia Shanghai Bell discussion Rel-17 FS\_NR\_redcap
12. R2-2007745 Considerations on RRM for reduced capability UEs LG Electronics France discussion Rel-17 FS\_NR\_redcap

RAN2\_112e

1. R2-2009022 Relax measurement for stationary and low mobility devices Intel Corporation discussion Rel-17 FS\_NR\_redcap
2. R2-2009087 RRM relaxation for power saving vivo, Guangdong Genius discussion Rel-17 FS\_NR\_redcap
3. R2-2009106 Discussion on RRM relaxation OPPO discussion Rel-17 FS\_NR\_redcap
4. R2-2009364 Summary of email discussion 915 - UE power saving features CATT discussion Rel-17 FS\_NR\_redcap
5. R2-2009620 RedCap power saving enhancements Ericsson discussion FS\_NR\_redcap
6. R2-2009877 RRM relaxation for stationary UE with reduced capability Lenovo, Motorola Mobility discussion Rel-17
7. R2-2009917 Power saving and battery lifetime enhancement for REDCAP UE Nokia, Nokia Shanghai Bell discussion Rel-17 FS\_NR\_redcap
8. R2-2009935 eDRX and RRM measurement relaxation for RedCap UE Huawei, HiSilicon discussion Rel-17 FS\_NR\_redcap
9. R2-2010580 RRM relaxation for stationary RedCap Ues LG Electronics Inc. discussion Rel-17 FS\_NR\_redcap
10. R2-2010592 RRM relaxation for RedCap devices Samsung Electronics discussion Rel-17
11. R2-2010787 Summary of offline 114 - RedCap power saving CATT discussion Rel-17 FS\_NR\_redcap

RAN2 endorsed TP

1. R2-2011165 TP for TR38875 Ericsson discussion FS\_NR\_redcap