**3GPP T****SG-RAN WG2 Meeting #113bis-e R2-2104361**

**Online, April 12 – 20, 2021**

**Agenda item: 8.12.3.2**

**Source: Qualcomm Incorporated**

**Title: Summary of [AT113-e][102][RedCap] RRM relaxations**

**WID/SID: FS\_NR\_redcap**

**Document for: Discussion and Decision**

# Introduction

This document is for the initial round of offline discussion on RRM relaxations for R17 stationary UEs. We will focus the discussion on the following three topics:

1.     Definition of stationarity,

2.     RRM relaxation criteria in RRC Idle/Inactive,

3.     RRM relaxation criteria in RRC Connected.

As the goal of this offline is to help facilitate efficient online discussion in the GTW session, we focus on only proposals related to the key issues and hence may not cover all specific enhancements proposed in the contributions. In addition, relaxation methods or network control/signalling aspects etc are NOT discussed in this offline.

Deadlines:

* Initial deadline for companies' feedback: **Tuesday 2021-04-13 14:00 UTC**
* Initial deadline for rapporteur's summary: **Tuesday 2021-04-13 18:00 UTC**

# Discussion

## Definition of stationarity

Different definitions of stationary UEs for the purpose of R17 RRM relaxations have been proposed in the contributions ([1]~[19]). They can be broadly categorized in the following three options:

Option 1: UE determines its stationarity ***only*** base on an enhanced version of R16 low-mobility criterion ([5], [8], [10], [17], [18], [19]) (*Note: Details of the enhancement to R16 criterion will be discussed in a later question*);

Option 2: UE determines its stationarity ***only*** base on its subscription information ([6], [7], [15]);

Option 3: ***Either*** Option 1 and Option 2 may be used by UE to determine its stationarity, depend on the type of stationarity that UE has. For example, if a UE’s location is fixed, it may determine its stationarity based on information provisioned in its subscription, without evaluating RSRP-based stationarity criterion such as the one described in Option 1 ([1], [3], [4], [16], [11], [14]).

Option 4: R16 low-mobility criterion [12] is sufficient.

Companies are invited to comment in the question below on which of the above options they prefer to use in determining whether a UE is stationary. Since no company discussed the necessity in having different definitions of stationarity in different RRC states, it is assumed that the same definition is used in all RRC states, unless one indicates otherwise in the Comments column.

**Question 1: Among the three options described above, which one do you prefer for defining UE’s stationarity?**

|  |  |  |
| --- | --- | --- |
| Company | Preference  (1, 2, 3, or 4) | Comments (if any) |
| Nokia, Nokia Shanghai Bell | 4 | We think that REL16 relaxation triggering condition is sufficient and we assume that RedCap device can implement RRM relaxations specified in REL16 for IDLE/INACTIVE and the same condition for relaxation shall be used also for CONNECTED as per WID objectives:  “for RRC\_Connected the mechanism reuses the Rel-16 RRM relaxation criteria from RRC\_Idle/Inactive” |
| Apple | 3 | RedCap has some unique mobility attributes and these need to be used (either by UE explicitly informing via subscription or capability, and/or by NW configuring enhanced thresholds that reflect the RedCap mobility characteristic) |
| Qualcomm | 3 | We think stationary UEs, due to their more predictable channel conditions, can benefit from further relaxations than those for R16 low-mobility UEs. Hence it is worthwhile to define them separately.  For UEs with fixed locations, we expect they would have much less fluctuation in their S measures than other UEs (even low-mobility ones). Hence it is feasible for them to use some preconfigured/provisioned information to determine their stationarity instead of going through some RSRP based evaluation process. That would enable faster triggering of RRM relaxation and thus more power savings for them. |
| Ericsson | Not 2/3 | From WID:   * RRM relaxations for neighbouring cells for RedCap devices: for RRC\_Idle/Inactive/Connected, considering the alternatives identified in the RedCap SI:   + Study until RAN#92e, and, if agreed, specify RRM measurement relaxation criteria (where, for RRC\_Idle/Inactive the Rel-16 mechanism is the baseline, and for RRC\_Connected the mechanism reuses the Rel-16 RRM relaxation criteria from RRC\_Idle/Inactive so as to maximize the commonality with Idle/Inactive UEs) [RAN2]     - Enabling/disabling of RRM relaxation should be under the network’s control. Specify both broadcast and dedicated signalling for enabling/disabling of RRM relaxation.   + After RAN#92e, if agreed in RAN2, specify RRM measurement relaxation [RAN4]   + No RRM relaxations are specified for the serving cell.   Based on this, we assume the discussion we are having here is which option we should study further? I.e. is there any alternative we can exclude even without have done any evaluation? Assuming this, we say:  Option 2 (subscription info) has been evaluated by RAN2 earlier but was excluded. One of the drawbacks is that it is not reliable, e.g. what happens when the UE starts to move?  Hence, we think that option 1 can be further studied and evaluated. |
| vivo | 3 | According to the previous discussion, it is widely believed that R16 RRM relaxation mechanism can be a starting point for the R17 RRM relaxation. Besides, introducing 2 relaxation levels (i.e. for fixed and moving UEs respectively) for RedCap UEs is considered which could provide enough flexibility to save the UE power for different scenarios. Thus, it is better to apply option1 in Rel-17.  Although one may argue option2 is only applicable to limited scenarios (UE is expected to be stationary or moving slowly in a localized area), it needs to notice a large percentage of RedCap UEs are expected to be used in the target scenarios of option2, e.g. Video Surveillance, industrial wireless sensors in an automated assembly line, Handling robot in a warehouse. From the implementation perspective, the enhancements are expected to be very simple and easy to use. Therefore, the cost to apply this enhancement is expected to be very low. For RedCap UEs in the above scenarios, we assume they are more power sensitive, so it is expected to have more/longer relaxation for RRM measurement. Thus, we prefer to support the solution in option2. |
| Intel | 3 | For fixed UE, subscription based approach is sufficient, and faster than measurement based approach. For temporary stationary UE, enhancements on R16 criteria is needed in order distinguish between them. |
| Futurewei | 1/4 | We are open to enhancements to R16 low-mobility criterion. |

Within the Option 1 above, there are different views on what the additional enhancements to the R16 low-mobility criterion should be:

Option 1a: Configure a separate set of thresholds (e.g. SSearchDeltaP and/or TSearchDeltaP) in the R16 low-mobility criterion for stationary UEs ([1], [3], [4], [10], [19]);

Option 1b: In addition to Option 1.a, also take in account changes in serving cell beams (e.g. whether number of beam changes within a period is less than a threshold) in the definition of stationarity ([3], [7], [8], [17], [18], [16]).

Option 1c: Without a separate set of thresholds but instead rely on the (single) set of thresholds from Rel-16, also take in account changes in serving cell beams (e.g. whether number of beam changes within a period is less than a threshold) in the definition of stationarity ([5]).

Companies are invited to comment below on which of the above two options is preferred.

**Question 2: If you have selected Option 1 or Option 3 in Question 1, which one do you prefer between Option 1a and 1b?**

|  |  |  |
| --- | --- | --- |
| Company | Preference  (1a or 1b) | Comments (if any) |
| Apple | 1b | 1b includes 1a as well. |
| Qualcomm | 1a | We think 1a is robust enough for the purpose. Beam change may not add much value to the evaluation of UE’s stationarity, for the following reasons.   1. In RRC Idle/Inactive, UEs use only SSBs for their RRM measurements. Since SSBs are wide beams, a UE with fixed location or low speed may not experience frequent changes in the set of beams it monitors between its RRM measurement instances. 2. Another counter example can be a UE located near cell center but experiences periodic signal blockage on its neighbor cell beams. Although this UE may have frequent beam changes, it is still safe for it to relax its RRM measurements on neighbor cells. |
| Ericsson | Not 1a/1b  Continue to study 1c | So far no one har really shown that the gain exceeds the “cost” of adding a new set of thresholds (1a or 1b). So until that has happened we think we can exclude these options.  We do think that RAN2 could continue to study if changes in beams brings any meaningful gain (which is worth the pain) and if so we could consider specifying that. By the way, since option 1b had option 1a included, we created option 1c. |
| vivo | 1a | We prefer to specify 2-level relaxation criteria and corresponding relaxation methods by configuring a separate set of thresholds (e.g. SSearchDeltaP and/or TSearchDeltaP) on top of the R16 low-mobility criterion for stationary UEs.  The main motivation of option1b/1c is to detect UE moving among beams but without changing the cell level measurement results. As we known, the measurement result of beam is not stable and changes fast. Hence, it may cause misjudgment on UE’s movement state, which may lead to more power consumption or mobility issue.  With this in mind, we think option1b can be considered with low priority. We could also accept it if majority agree its feasibility. |
| Intel | 1b | To consider 2 level mobility as agreed in SI phase, additional threshold is needed. In addition, the beam switching should also be considered since the cell level measurement may be same when the UE moves among beams. |
| Futurewei | 1b | Beam quality change can be used in evaluating “stationarity” |

## RRM relaxation in RRC Idle/Inactive

As to triggers for RRM relaxation in RRC Idle/Inactive, most contributions ([1] [8] [16] [18] [19]) except one ([12]) support reusing the R16 RRM relaxation triggering criteria, with the R16 low-mobility criterion replaced by the R17 stationarity criterion discussed in Section 2.1. More specifically,

* If a R17 UE determines that it is stationary (based on the definition(s) to be agreed in Question 1 and 2), then it can apply relaxation methods associated with the stationary criterion (the exact methods are to be discussed later);
* If not-at-cell-edge criterion is also configured and this UE meets that criterion, then it can apply relaxation methods associated with both stationary and not-at-cell-edge criteria (the exact methods are to be discussed later).

Please note that the exact relaxation methods associated with the different criteria specified above are not within the scope of this offline discussion and will be discussed later.

Companies are invited to indicate their preference on the above proposal in the following question:

**Question 3: Do you support reusing the R16 RRM relaxation triggering criteria for R17 stationary UEs in RRC Idle/Inactive, with the R16 low-mobility criterion replaced by the R17 stationarity criterion?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (if any) |
| Nokia, Nokia Shanghai Bell | No | We think that REL16 relaxation triggering condition is sufficient for IDLE/INACTIVE, |
| Apple | Yes | This would be the direction to go, with details discussed later. |
| Qualcomm | Yes | See our comment to Question 1. |
| Ericsson | See comment | We understand the question to mean that: in case RAN2 enhances the criteria used to determine low/no mobility as per question 2, then that enhanced criteria could be used to apply a potential Rel-17-way of relaxing measurements. I.e. the Rel-16 criteria is replaced by the Rel-17 criteria? If that understanding is correct, our response is "Yes". |
| vivo | Yes | This allows the reuse of existing mechanism and avoids repeating the discussion in R16. |
| Intel | Yes (comments) | I assume question is “low mobility” and “not at cell edge criterion” are applicable for R17 stationary UE with enhancements. Then our answer is yes. |
| Futurewei | Yes | We support this as a general direction to take for now, with details to be discussed later. |

It is proposed in [1] and [19] that because stationary UEs have less uncertainties in their mobility than low-mobility UEs, separate thresholds (e.g. SSearchThresholdP\_Stationary and/or SSearchThresholdQ\_Stationary) used in the R16 not-at-cell-edge criterion can be introduced for R17 stationary UEs.

Companies are invited to indicate their preference on the above proposal in the following question:

**Question 4: If you answered “Yes” in Question 3, do you support introducing separate thresholds, SSearchThresholdP\_Stationary and/or SSearchThresholdQ\_Stationary, for the not-at-cell-edge criterion for R17 stationary UEs in RRC Idle/Inactive?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (if any) |
| Apple | Yes |  |
| Qualcomm | Yes | Because stationary UEs have more predictable mobility, the thresholds for not-at-cell-edge criterion can be further relaxed than those used in R16. |
| vivo | Yes | Besides, we have agreed that some reduced capabilities for RedCap UEs, e.g. at least both the number of Rx antennas and maximum bandwidth supported by RedCap UEs are smaller than non-RedCap UEs, which may cause some difference in the measurement results for RedCap UE comparing with non-RedCap UEs. In this way, when reusing the existing criteria in Rel-16 to RedCap UEs, we should consider introducing separate thresholds (e.g. SSearchThresholdP\_Stationary and/or SSearchThresholdQ\_Stationary) for R17 stationary RedCap UEs. |
| Intel | Yes |  |
| Futurewei | Yes |  |
|  |  |  |

It is possible that network may configure both R16 and R17 RRM relaxations at the same time. [1][6][8] discuss what UE behaviors should be in this case. Their proposals are captured in the following options:

* Option 1: If a R17 stationary UE satisfies more than one R16/17 RRM relaxation criteria configured by network, it should be up to UE implementation to choose which criterion(a) to apply relaxation methods [1];
* Option 2: If RedCap UE fulfils the R16 RRM relaxation criteria, then R16 RRM relaxation method is applied without further enhancement. The legacy lowMobilityEvaluation-r16, cellEdgeEvaluation-r16 parameters are applicable to both RedCap and non-RedCap UEs [6];
* Option 3: A R17 UE evaluates the R17 RRM relaxation criterion first; if it is not fulfilled, fall back to R16 RRM relaxation [8].
* Option 4: R16 low-mobility criterion [12] is sufficient
* Option 5: A R17 UE evaluates the R17 RRM relaxation criterion if configured by the network;

Companies are invites to indicate which of the above options they support in the follow question:

**Question 5: Among the three options described above, which one(s) do you support?**

|  |  |  |
| --- | --- | --- |
| Company | Preference  (1, 2, 3 or 4) | Comments (if any) |
| Nokia, Nokia Shanghai Bell | 4 | We think that R16 RRM relaxation criteria is sufficient |
| Apple | 3 | But we also think its up to NW configuration and NW can just use R17 config for R17 RedCap UEs |
| Qualcomm | 1 | Since R17 UEs do not need to take separate measurements for R16 and R17, a single set of S measures can be used by a R17 UE to evaluate both R16 and R17 relaxation criteria. Hence there does not exist any particular order for UE to follow in its evaluation of relaxation criteria.  If network configures both R16 and R17 relaxation criteria and a R17 UE meets both criteria, then the UE should be allowed to decide by itself which release’s criterion it may choose to apply. |
| Ericsson | None | Again, this seems to be something RAN2 can discuss if it is decided that we should specify anything.  Anyway, on the technical question, it seems unnecessary complex that a UE considers two different evaluation criteria and then we need to sort out which criteria is "active" at which point in time, and priorities between the Rel-16 and Rel-17 criteria.  We always assumed and hoped that RAN2 should go for a simple solution where RAN2 may in Rel-17 "enhance" the Rel-16 criteria. A Rel-17 UE would then apply those criteria… without any if:s and but:s. I.e. the UE would not evaluate a Rel-16 set of criteria and a Rel-17 set of criteria and select between these two.  If RAN2 are considering a solution this complex, perhaps it is not worth the effort? |
| vivo | 3 / 1 | In our understanding, R17 would provide more power saving gains than R16, assuming more critical criteria would be defined. In this way, R17 RRM relaxation methods (with more relaxation) should be applied even if both R16 and R17 RRM relaxation criteria are satisfied.  Otherwise (i.e. RRM relaxation in R17 may have less relaxation than R16), it should be up to UE implementation to decide which relaxation approach should be applied. |
| Intel | 5 | The UE shall follow network guidance. If the network indicates R17 criteria, then R17 UE shall only use it. |
| Futurewei | 5 | Agree with Intel. |

## RRM relaxation in RRC Connected

Among the submitted proposals, there are two different approaches to design relaxation criteria for stationary UEs in RRC Connected. One approach is “to reuse”, e.g. either use R16 relaxation criteria (e.g. low-mobility, not-at-cell-edge) as baseline or use the same criteria as the R17 relaxation criteria to be developed for stationary UEs in RRC Idle/Inactive. The other approach is to introduce new relaxation criteria.

Among the proposals supporting the “reuse” approach, there are two approaches with subtle differences, which are described in the following:

* Option 1a: A R17 stationary UE in RRC Connected applies the same types of RRM relaxation criteria as those for RRC Idle/Inactive. FFS whether parameters used in the relaxation criteria and relaxation methods can be different [1]. This approach is based on the observation that for stationary UEs, there is no fundamental difference in their neighbor cell measurements in RRC Connected and RRC Idle/Inactive. Hence RAN2 may prioritize the discussion on RRC Idle/Inactive relaxations and then reuse them for RRC Connected.
* Option 1b: R16 mechanism can be taken as baseline for neighbour cell measurement relaxation for R17 stationary UEs in RRC connected [2][12][17]. What this approach suggests is that RAN2 will separately study relaxation criteria that are based on R16 relaxation criteria for RRC Connected. RAN2 may or may not develop different relaxation criteria for RRC Connected and RRC Idle/Inactive for R17 stationary UEs.
* Option 1c: RRC\_Connected reuses the Rel-16 RRM relaxation criteria from RRC\_Idle/Inactive as per WID

Among the contributions supporting new criteria for RRC Connected, there are two proposals:

* Option 2a: Introduce a new parameter, s-MeasureConfig\_Stationary, configured within MeasConfig. A stationary UE decides whether to relax its RRM measurements based on the new stationary criterion and how the RSRP of its SpCell compares against s-MeasureConfig\_Stationary [19];
* Option 2b: Introduce beam based criterion for allowing/disallowing RRM measurement relaxation in RRC Connected [12].

Companies are invited to indicate their preference on the various proposals described above in the following questions:

**Question 6. Do you prefer “reuse” (Option 1a & 1b) or introduce new relaxation criteria (Option 2a & 2b)?**

|  |  |  |
| --- | --- | --- |
| Company | Reuse or new | Comments (if any) |
| Nokia, Nokia Shanghai Bell | Reuse | It is already very clearly defined in the WID that Rel-16 relaxation criteria shall be used:  “for RRC\_Connected the mechanism reuses the Rel-16 RRM relaxation criteria from RRC\_Idle/Inactive” |
| Apple | reuse |  |
| Qualcomm | Reuse |  |
| Ericsson | None | We do not think we should introduce any relaxation in CONNECTED. Note that the network could, when it has determined that a UE is of low/no mobility simply deconfigure RRC measurements for the UE if the network finds suitable. However, as was noted in some of the contributions: RRM measurements are **not only** performed for mobility. For example, the network may need measurements from the UE for the sake of load balancing and the UE shall of course not relax measurements.  So, in CONNECTED the network is in full control of which measurements the UE performs and can adjust the measurements freely, e.g. also based on observed mobility of the UE. There is no need for any enhancements.  In our paper we suggested that RAN2 can investigate if any UE to network reporting of the mobility of the UE would be beneficial. So far there has not been shown any real gains of this, but we are open to keep evaluating this. |
| vivo | Reuse | We agree with Rapporteur’s observation that that for stationary UEs, there is no fundamental difference in their neighbor cell measurements in RRC Connected and RRC Idle/Inactive. Meanwhile, to save the time for discussion on RRM relaxation, it is more reasonable to reuse criteria from RRC Idle/Inactive to RRC Connected. |
| Intel | See comments | The first question should be whether we consider both fixed UE and temporary stationary UE. If we consider both of them, then IDLE/INACTIVE approach could be “reused” but changes are needed to adapt CONNECTED mode, e.g. subscription based approach, RAN may get this information from CN. |
| Futurewei | Reuse |  |

If you selected “reuse” in Question 6, please indicate your preference between Option 1a and 1b in the following question:

**Question 7: For R17 stationary UEs in RRC Connected, do you prefer applying the relaxation criteria to be developed for R17 stationary UEs in RRC Idle/Inactive (Option 1a), or separately studying the relaxation criteria based on the existing R16 relaxation mechanism (Option 1b)?**

|  |  |  |
| --- | --- | --- |
| Company | Preference  (1a or 1b or 1c) | Comments (if any) |
| Nokia, Nokia Shanghai Bell | 1c | It is already very clearly defined in the WID that Rel-16 relaxation criteria shall be used:  “for RRC\_Connected the mechanism reuses the Rel-16 RRM relaxation criteria from RRC\_Idle/Inactive” |
| Apple | 1a |  |
| Qualcomm | 1a | We do not see any fundamental difference in the neighbor cell measurement relaxation criteria between RRC Idle/Inactive and RRC Connected. Hence whatever relaxation criteria we agree in one RRC state can be applied to the other. |
| Vivo | 1a | We agree with Qualcomm. Besides, we think RedCap UEs may have different measurement performance from non-RedCap UEs due to reduced capabilities. Thus, it is more proper to reuse the criteria to be developed for R17 stationary UEs but not the criteria based on existing R16 relaxation. |
| Futurewei | 1a |  |
|  |  |  |

If you selected “new” in Question 6, please indicate whether you support Option 2a and 2b described above in the following question. If you do not support either Option 2a or 2b but have other proposals for new relaxation criteria, you may indicate “other” as your preference and your motivation in the Comments column.

**Question 8: Do you support introducing a new threshold against RSRP of UE’s SpCell as described in Option 2a, or beam based criterion as described in Option 2b, or other enhancements?**

|  |  |  |
| --- | --- | --- |
| Company | Option 2a, 2b or other | Comments (if any) |
|  |  |  |
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The last issue to discuss is whether it is UE or network that has the power to trigger measurement relaxation when UE meets relaxation criteria. Two types of approaches have been proposed in the contributions, as follows:

* Option 1: If network provides evaluation parameter for relaxation criteria (either in SIB or by dedicated signaling), UE can relax its RRM measurements on neighbor when it meets the relaxation criteria [1] [2] [12] [17];
* Option 2: When UE meets relaxation criteria configured by network, it provides an indication to network and then wait for network’s confirmation to trigger its relaxation. This indication from UE can be in the form of a measurement report [2] or other signaling method [18].
* Option 3: Only UE to network indication is considered, but existing procedures already in spec are used to achieve relaxation, e.g. deconfigure measurements.

Companies are invited to indicate their preference between the above two options:

**Question 9: Do you think UE is allowed to trigger relaxation by itself after meeting the relaxation criteria configured by network (Option 1) or UE always needs a confirmation from network to trigger relaxation even after UE has met the relaxation criteria (Option 2)?**

|  |  |  |
| --- | --- | --- |
| Company | Preference  (Option 1 or 2) | Comments (if any) |
| Nokia, Nokia Shanghai Bell | 2 | We assume that this question is only for CONNECTED |
| Apple | No strong preference, but 2 is feasible as the UE is in CONNECTED mode |  |
| Qualcomm | 1 | If network has configured relaxation criteria, that means network authorizes UEs to evaluate relaxation criteria by themselves. Otherwise, network can evaluate UE’s eligibility by itself based on UE’s measurement reports (this can be done in RRC Connected but no RRC Idle). Hence we do not see any need for an extra signaling step by UE to get a confirmation from network before it can trigger RRM relaxations. |
| Ericsson | 3 | As said, the network is in full control over which measurements a UE in CONNECTED needs to perform. The network can deconfigure measurements if deemed suitable by the network.  Our interpretation of option 2 above seem to be some type of new mechanism should be added? But a simple deconfiguration of measurements will suffice and luckily(!) RAN2 does not need even to change the spec for this. |
| vivo | 1 and 2 | We think the network is in full control even in option1, as the network can decide how and even whether to configure the parameters for RRM relaxation.  In our understanding, it is too early to make the decision on this issue. We could agree to list the options here from RAN2 point of view. After RAN4 defining the relaxation method based on the criteria developed above, we could further discuss which approach should be adopted in both RAN2 and RAN4. |
| Intel | 1 | The relaxation criteria is configured by the network, and therefore the network already have full control on this , i.e. the network can decide whether the UE is allowed to do this, and based on what. Therefore the UE can follow network guidance and relax RRM measurement directly when the criteria (configured by network ) is met. |
| Futurewei | 2 |  |

# Conclusion

# Contact information

|  |  |
| --- | --- |
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