**3GPP TSG RAN WG1 Meeting #103-E R1-200xxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Moderator summary #3 on RedCap - Others**

**Agenda item: 8.6.5**

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

# Introduction

This document presents a summary of submitted contributions to AI 8.6.5 (Other aspects of RedCap) and some contributions to AI 8.6.4 that have discussions relevant to RedCap UE identification and access control.

Based on the submitted contributions to RAN1 #102-E meeting, the discussion points are categorized into the following topics:

* Access control
* Identification of RedCap UEs by the NW
* RRM relaxations for power savings

**In this version of the summary, a new sub-section (3.1) has been added with new questions marked in Turquoise (e.g., Questions 3.1.1-F/N/P, etc.). To better focus the discussion, the analysis in Sub-section 3.1.4 on Opt. 4 will be updated further once discussion on Options 1 through 3 are a bit stable.**

# Access control

The SID on RedCap lists the following objectives:

*Study functionality that will allow devices with reduced capabilities to be explicitly identifiable to networks and network operators, and allow operators to restrict their access, if desired [RAN2, RAN1].*

During RAN1 #102-e meeting, the following was discussed in RAN1 without conclusion [29]:

|  |
| --- |
| *Updated FL Proposal 1 (from RAN1 # 102-e)** *Further study the options to realize cell barring for RedCap UEs, including ~~at least~~ the following indication methods:*
	+ *Implicit or explicit indication (as may apply):*
		- ***Alt. A****: Via separate SSB and/or CORESET 0.*
		- ***Alt. B****: Via indication in MIB.*
		- ***Alt. C****: Via indication in DCI format scheduling SIB1.*
		- ***Alt. D****: Via indication in SIB1.*
		- *Other methods are not precluded.*

*Note: This study intends to establish feasibility of, and pros and cons for the identified methods from RAN1 perspective, without any intention of down-selection without guidance from RAN2.* |

In the meantime, RAN WG2 decided on the following:

|  |
| --- |
| 1. An indication in system information is needed to indicate whether a REDCAP UE can camp on the cell. FFS whether the indication is explicit or implicit.
2. UAC mechanism also apply to REDCAP UEs.
3. System information indicates whether REDCAP operation is allowed/barred on a frequency. FFS reuse the legacy intraFreqReselection or introduce separate flag
4. Further discuss enhancement of UAC for REDCAP UEs, including e.g.:
	1. define new Access Identity for REDCAP UEs
	2. define new Access Categories for REDCAP UEs

(for any final decision we need to check with SA1 and/or CT1) |

Some contributions ([5], [9], [10], [17]) have presented discussions on access control mechanisms beyond the above-quoted RAN WG2 agreement, highlighting potential benefits from additional/supplementary mechanisms beyond RAN2 agreement of indication of support of RedCap UEs in a cell via SIB1 – specifically, via use of PDCCH/DCI format scheduling SIB1 PDSCH. However, given the agreement in RAN WG2, whether additional mechanisms are necessary or warranted is not obvious at this point (e.g., Proposal 2 in [19]).

The issue of access control is being discussed further in RAN WG2, and there exists various dependencies on decisions related to, e.g., configuration of separate DL/UL initial BWPs for RedCap UEs, support of a separate SIB1 for RedCap UEs, etc., some of which needs to rely on decisions in RAN WG2. Thus, at this point, it may be prudent to wait for RAN WG2 to make further progress, especially considering the related discussions during RAN1 #102-e meeting. This view (to wait for further progress in RAN WG2) is expressed by several contributions as well (e.g., [2], [6], [19]).

## FL Proposal 1

* *On the issue of access control for RedCap UEs, RAN1 to wait for further progress in RAN2.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | Y |  |
| Panasonic | Y |  |
| LG | Y | RAN1 specific solution such as using DCI could be discussed in RAN1 as well. |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Convida | Y | Based on our understanding, RAN2 agreements do not preclude considering RMSI-PDCCH. Therefore, we think that RMSI-PDCCH can be still discussed in RAN1 pending RAN2 progress. |
| ZTE |  | Use of PDCCH/DCI format scheduling SIB1 PDSCH can bring additional power saving. Since this is the last meeting in RAN1, as proposed, waiting further progress in RAN2 means RAN1 related solution is precluded even though it is beneficial.Since use of PDCCH/DCI format scheduling SIB1 (Alt C) is within RAN1 scope and has no impact on RAN2 spec, we hope the feasibility and benefit of Alt C can be discussed in RAN1 in this meeting.  |
| CATT | Y |  |
| Huawei, HiSilicon | N | RAN1 can continue the discussion from RAN1 perspective. There is no need for any specific conclusion. Particularly one thing we may be decide within SI is that whether the network capability for supporting RedCap UE accessing should be indicated to UEs or not. With this high level conclusion it would help RAN2 signalling design in later WI phase.Moderator: This seems already agreed now according to RAN2 decision quoted above. |
| OPPO | Y |  |
| Samsung | Y |  |
| CMCC | Y | Same view with LG, some RAN1 specific solution can be discussed parallel with RAN2 |
| DOCOMO | Y |  |
| Lenovo, Motorola Mobility | Y | To us, the RAN2 agreement is clear. There is an indication in system information to indicate if RedCap UEs could access the cell.  |
| Nokia | N | Similar opinion to Huawei, CMCC, LG.RAN1 can continue the discussion of access control from the RAN1 perspective. |
| WILUS | Y |  |
| Xiaomi | N | RAN1 could discuss this issue in parallel |
| Spreadtrum | Y |  |
| Ericsson | Y | In our view, RAN1 should continue to prioritize study of other aspects of the study item and leave the study of access control to RAN2. |
| Apple  | Y | Support FL proposal as access control procedure is typically handled by RAN2 and maintained in RAN2 specification. Nothing is special for Redcap study item. Should leave to RAN2.  |

## Summary (FL Prop 1):

* 16 companies indicate that they are fine for RAN1 to wait for RAN2 to make further progress on access control.
	+ However, 3 out of these 16 also indicate that they think RAN1 can also discuss any Layer 1 signaling solutions in parallel.
* 4 companies do not agree with the proposal and would like to study Layer 1 signaling solutions.

The RAN2 agreement says:

An indication in system information is needed to indicate whether a REDCAP UE can camp on the cell. FFS whether the indication is explicit or implicit

Given that there is an FFS on whether the indication is explicit or implicit, and the fact that in the recent RAN2 email discussion (RAN2 email discussion #914) almost all companies seem to have indicated that details beyond the above agreement should be considered during WI phase, the option of using DCI format/PDCCH scheduling system information is not precluded and can still be considered during the normative phase. For reference, the RAN2 email discussion rapporteur’s recommendation based on received feedback is quoted below:

|  |
| --- |
| **Proposal 8: Postpone the discussion on the camping indicator for RedCap UEs to the WI phase.** |

At this point, from RAN1’s perspective, no solution is being ruled out, and given that at least 13 companies feel that we can work out the next level of details during the WI phase, and this is not critical to the conclusion of the SI, it is recommended to postpone discussion of exact signaling solutions associated with system information to a latter phase.

The proposal is now updated as below to better align with the proposal being tabled in RAN2 and to clarify the scope further in light of the RAN2 decisions.

## FL Proposal 1A

* *For access control for RedCap UEs, detailed signaling options associated with system information are postponed to the WI phase.*

# Identification of RedCap UEs

The SID on RedCap lists the following objectives:

*Study functionality that will allow devices with reduced capabilities to be explicitly identifiable to networks and network operators, and allow operators to restrict their access, if desired [RAN2, RAN1].*

As can be seen from the above, it is imperative that RedCap Ues can be identified by the network without ambiguity. Here, it is noted that such identification is relevant primarily in the context of accessing a cell (as against merely camping on a cell).

In contributions [2], [4], [5], [8], [10], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22] views on realizing the objective of access control for RedCap Ues have been presented. Please refer to Appendix A for list of observations and proposals from these contributions related to identification for RedCap Ues by the NW.

During RAN1 #102-e meeting, the following was agreed [29]:

|  |
| --- |
| *Agreements:** *Further study the options for identification of RedCap Ues, including ~~at least~~ the following indication methods:*
	+ *Opt. 1: During Msg1 transmission, e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning.*
	+ *Opt. 2: During Msg3 transmission.*
	+ *Opt. 3: Post Msg4 acknowledgment.*
		- *E.g., during Msg5 transmission or part of UE capability reporting.*
	+ *Opt. 4: During MsgA transmission (subject to support of if 2-step RACH)*
	+ *Other options are not precluded.*
	+ *Note: This study intends to establish feasibility of, and pros and cons for the identified options from RAN1 perspective, without any intention of down-selection without guidance from RAN2.*
 |

In general, how early such identification needs to be made depends on the physical layer procedures for RedCap Ues regarding random access and whether there may be differences for RedCap Ues compared to regular NR Ues. In case different handling of RedCap Ues is required for random access, then early identification either via Msg1 or Msg3 may be necessary.

Some cited motivations for early identification of RedCap Ues include:

* **Coverage:** Different coverage performance for RAR and/or Msg4 for RedCap Ues compared to regular NR Ues 🡪 this may necessitate different scheduling approaches for Msg2/Msg4 and Msg3 (use of repetitions, etc.).
	+ *Even if Msg2/Msg3/Msg4 may not necessarily need coverage enhancements/recovery, the knowledge that a UE initiating a random-access procedure is a RedCap UE can be beneficial in realizing appropriate DL and UL link adaptation for Msg2/Msg3/Msg4 scheduling as well. However, the trade-off against increased OH, RACH capacity loss, etc.*
* **Initial UL BWP congestion:** Limitations to non-RedCap Ues by limiting max BW for initial UL BWP (e.g., 20 MHz in FR1, 50 MHz in FR2 (if supported))
	+ *Separation of initial UL BWPs for RedCap Ues from non-RedCap Ues could alleviate the restrictions that may otherwise impact non-RedCap Ues.*
	+ *However, since the initial UL BWP could be limited to random access related (Msg1, Msg3) transmissions, the overall adverse impact to non-RedCap Ues may not be significant as the non-RedCap Ues could be switched to larger UL BWPs upon RRC connection establishment.*
* **Initial DL BWP congestion:** Limitations to non-RedCap Ues by limiting max BW for initial DL BWP (e.g., 20 MHz in FR1, 50/100 MHz in FR2)
	+ *This impact is primarily limited to Msg4 scheduling for non-RedCap Ues, and UE identification via Msg1 or Msg3 could facilitate more flexible resource allocation for Msg4 scheduling for non-RedCap Ues.*
* **Minimum UE requirements impacting RA procedure:** It may be necessary to identify RedCap Ues at Msg1 transmission if minimum UE processing times for RedCap Ues are relaxed compared to Capability #1 values or requirements on UL waveform are relaxed (e.g., SC-FDM only) for RedCap Ues, etc.
	+ *In the absence of such knowledge upon reception of Msg1, the gNB may be forced to schedule RAR/Msg3/etc. conservatively in terms of minimum UE processing times or waveform support, thereby potentially causing adverse impact to non-RedCap UE’s control plane (CP) latency.*

On the other hand, if RedCap Ues can perform random access procedure like regular NR Ues, it may be sufficient if RedCap Ues are identified via Msg3 or even via Msg5 (upon connection establishment).

In summary, the necessity of early identification may not be clearly established until further clarity is achieved on related design choices for RedCap UE cost/complexity reduction and whether any new mechanisms related to initial access and system information acquisition are introduced (e.g., separate SIB1 for RedCap Ues, separate initial DL/UL BWPs for RedCap Ues, etc.). This is further complicated by the fact that such UE identification may not be limited to identifying RedCap Ues from non-RedCap ones, but also further identification of RedCap Ues.

Further, it has also been pointed out in several contributions that configurability of some of the features, e.g., separate RACH preambles, separate RACH resources, or separate initial UL BWP for RedCap Ues, may be considered further to realize some of the above-listed benefits for deployments that may merit from such enhancements. In other words, early identification of RedCap Ues (prior to UE capability reporting) may not be mandated but could be optionally configured by the gNB towards achieving the best trade-off between access latency, user capacity, and system OH, congestion control, and resource utilization in both DL and UL. This also implies that at least RedCap UE identification as part of UE capability reporting should be supported.

Thus, at this point, RAN1 could focus on establishing the feasibility of and identifying the pros and cons for the various options for RedCap UE identification while further details on RedCap UE capabilities/minimum requirements and related system design details attain further clarity.

## FL Proposal 2

* *As a next step, during RAN1 #103-e meeting, RAN1 to focus on establishing feasibility and identifying pros and cons for the following schemes:*
	+ ***Opt. 1****: During Msg1 transmission, e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning.*
	+ ***Opt. 2****: During Msg3 transmission.*
	+ ***Opt. 3****: Post Msg4 acknowledgment.*
		- ***E****.g., during Msg5 transmission or part of UE capability reporting.*
	+ ***Opt. 4:*** *During MsgA transmission*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | Y |  |
| Panasonic | Y |  |
| LG | Y |  |
| Futurewei | Y | Proposal 2 can include necessity as well. Per RAN2 decision, minimum fragmentation is needed, so for this discussion we should have only one option per band (no mixing of RedCap Ues using different initial access methods in the same band). Market fragmentation needs to be avoided. |
| Qualcomm | Y |  |
| Convida | Y |  |
| ZTE |  | Considering that Option 1 and Option 4 are mostly RAN1 related, RAN1 needs to focus on the study of necessity of identification of RedCap UE by Msg1/MsgA.  |
| CATT | Y | We also suggest separating ‘via separate initial UL BWP’ from Opt.1 (maybe another new option is needed). When discussing whether Msg1/3/5 is used to identify RedCap UE from normal NR UE, it is more common to assume that they share the same initial UL BWP. Some companies may prefer separate initial UL BWP but not using Msg1 division, and vice versa. BTW it seems a typo above the listed agreement? It was reached in RAN1#102-e, but not RAN1 #103-e.Moderator:  |
| Huawei, HiSilicon | Almost | As discussed during GTW, it is desirable to have some narrow down. Even not to down select to a single option but can still be helpful to narrow the scope for WI if there are multiple. However, in any case we don’t think the discussion here would directly lead to conclusion related to UE type – which would need to be used mainly for the purpose of differentiation from normal Ues as required in SID rather than differentiation among RedCap use cases. We suggest* *As a next step, during RAN1 #103-e meeting, RAN1 to focus on establishing feasibility and identifying pros and cons, and strive for narrowing down the possible solution(s) for early identification of RedCap Ues from ~~for~~ the following schemes:*
	+ ***Opt. 1****: During Msg1 transmission, e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning.*
	+ ***Opt. 2****: During Msg3 transmission.*
	+ ***Opt. 3****: Post Msg4 acknowledgment.*
		- ***E****.g., during Msg5 transmission or part of UE capability reporting.*
	+ ***Opt. 4:*** *During MsgA transmission*
 |
| OPPO | Y | Consider the early identification of RedCap Ues, the options can be further down-selected in RAN1.  |
| Samsung | Y |  |
| CMCC | Y | Same view as CATT to separate initial UL BWP from option 1, because if the separate initial UL BWP is used for RedCap UE accessing, there is no need to use separate PRACH/preamble as early identification. |
| DOCOMO | Y |  |
| Lenovo, Motorola Mobility | Y | We need list the motivations specific for each option, and see if any conclusions could be drawn for the motivations.  |
| Nokia | Almost | As per comments made in the GTW session, we should be striving for more than just feasibility and pros and cons, i.e. a recommended option. |
| WILUS | Y |  |
| Xiaomi | Y | Further down-selection can be performed to narrow down the candidates  |
| Spreadtrum | Y |  |
| Ericsson | Y | In our view, the study of feasibility already includes the study of necessity (i.e., if the system does not work when the RedCap UE indication is in MsgX, RedCap UE indication in MsgX is not a feasible solution), but it is fine to spell it out in the proposal.Note that the necessity of a RedCap UE indication option may not be a binary question, since it may be scenario dependent. As mentioned in the background text above the proposal, it may be desired to let the network decide which option to use. |
| Apple  | Y |  |

## Summary (FL Prop 2):

* There seems to be reasonable consensus on the intent of the proposal.
* Some companies suggest to explicitly capture “*necessity/motivation*” in addition to “*feasibility and identifying pros and cons*”.
	+ *Necessity was always intended to be included as part of the proposed study but it is now reflected explicitly in the updated version of the proposal.*
* Couple of companies suggest that we should at least strive for some level of pruning of the list of options during the SI phase itself.
	+ *We could strive to narrow down the list of solutions. However, this may not be quite practicable given that at least Options 2 and 3 cannot be decided by RAN1 without RAN2 consideration.*
	+ *However, RAN1 should certainly aim for eventual down-selection that could even be captured as observations from RAN1 perspective, based on a well-rounded summary of the different options.*
* Couple of companies suggest to split the option of using separate UL BWP from Option 1 in order to not confuse with Msg1 partitioning options
	+ *Here, it should be noted that Option 1 is not saying “Msg1 partitioning”, but says “During Msg1 transmission”, and for the sub-option of separate UL BWP configuration, Msg1 partitioning could indeed be avoided.*
	+ *Although not spelled out, it should be clear that variants, similar to the sub-options for Option 1, are also applicable for Option 4.*

The proposal is revised in consideration of the above points and with addition of an important context that got left out in the original proposal.

## FL Proposal 2A

* *As a next step,* *for the study on the options for RedCap UE identification during RAN1 #103-e meeting, RAN1 to focus on establishing feasibility, necessity, and identifying pros and cons for the following schemes:*
	+ ***Opt. 1****: During Msg1 transmission, e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning.*
	+ ***Opt. 2****: During Msg3 transmission.*
	+ ***Opt. 3****: Post Msg4 acknowledgment.*
		- ***E****.g., during Msg5 transmission or part of UE capability reporting.*
	+ ***Opt. 4:*** *During MsgA transmission.*

## FL Proposal 3

* *Under the assumption that RedCap UEs may be identified at least via UE capability reporting:*
	+ *Optional configurability of separate resources for Msg1/MsgA transmissions for RedCap UEs via use of separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning for early identification of RedCap UEs is considered further.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| vivo |  | Main bullet is fine but not sure about the intention of the sub-bullet, seems already covered by option 1 of FL proposal 2? |
| Panasonic |  | This is basically Opt.1. At this moment, it is too early to prioritize any of the options before concluding proposal 2 and discussion on that. |
| Moderator |  | To clarify the distinction w.r.t. Option 1 in FL proposal 2, while FL proposal 2 talks about the general applicability of each of the options for RedCap UE identification, FL Proposal 3 is highlighting a specific point that the mechanism for identification of RedCap UEs via Option 1 *can be considered*  as a supplementary mechanism that can be turned ON/OFF by the gNB. In other words, it may be up to gNB to decide whether to use Option 1/4 or Option 3 (Msg5+).The feasibility of such optionality relies on the main bullet in FL Proposal 3, and there seems to be interest in such consideration at least for Options 1 and 4 (MsgA now added to FL Proposal 3 above for completeness), while that for Option 3 may be a bit less clear. |
| LG |  | We think that early indication to REDCAP UE in MSG1/A is used for gNB to understand REDCAP UE during initial access. Meanwhile, UE capability reporting is normally used for gNB to understand capability of connected UEs. For the time being, it is unclear whether gNB can understand REDCAP UEs without such early indication during initial access. We propose to discuss optionality of early indication during WI phase. |
| Futurewei | Y | This solution has the advantage of being similar to the LTE solution |
| Qualcomm |  | Thanks for drafting this proposal.We are fine with the general description of “Optional configurability of separate resources for Msg1/MsgA transmissions.” It is ok to include “via use of separate PRACH resource, or PRACH preamble partitioning for early identification of RedCap UEs.” However, the configuration of separate initial UL BWP has not been discussed yet for RedCap UE. Therefore, we think it is not necessary to include “via use of separate initial UL BWP” in the FL proposal. Moderator: To be fair, all of these options have been discussed by multiple companies in their contributions. Thus, we Regarding the use of separate PRACH resources, could FL clarify if it covers different PRACH formats (e.g. RedCap UEs use long PRACH preamble of length 839, and eMBB UEs use short PRACH preamble of length 139) and/or different PRACH occasions ?Moderator: Yes, separate PRACH resources can include both occasions and formats. |
| Convida |  | It may be too early to discuss the possibility of allowing the gNB to turn On/Off the UE identifications via Msg1/MsgA. Moreover, when using MsgA, it seems that sub-bullet precludes other mechanisms that depends on MsgA-PUSCH and only mentions aspects related MsgA-PRACH. |
| ZTE |  | We think this proposal is related to the feasibility of Option 1. RAN1 can study potential solutions to support identification of RedCap UE by Msg1. |
| CATT |  | See also our comments in Proposal 2. We have similar views with Qualcomm that ‘separate initial UL BWP’ is different from other methods in Option1. Configuring and indicating another initial UL BWP is not as simple as configuring separated Msg1 resource (no matter by preambles or by time-frequency resource).  |
| Huawei, HiSilicon | Almost | We understand the intention of the FL proposal 3. Following the FL proposal 2 this can be a good starting point for next step discussion - i.e. firstly identify the feasibility of Option 1 and pros and cons. Similar observations for other options can be made in line with this from proponents. We don’t think the main bullet is necessary and actually may lead to different understanding of early identification – which is supposed to be before RRC connection.* *For early identification of RedCap UEs ~~Under the assumption that RedCap UEs may be identified at least via UE capability reporting~~:*
	+ *At least for Option 1, Optional configurability of separate resources for Msg1/MsgA transmissions for RedCap UEs via use of separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning for early identification of RedCap UEs is considered further.*
 |
| OPPO |  | Proposal 3 is only related to option 1 of proposal 2. This should be clarified in the proposal. And it can be deprioritized before the options in proposal 2 are down-selected. |
| Samsung |  | It would be better to discuss the options in Proposal 2 and conclude if all/some options should be considered further. Then we can discuss turning ON/OFF the identification mechanism with option 1. |
| CMCC | Y |  |
| DOCOMO | Y | Assuming that Proposal 2 would be agreeable, Proposal 3 can be a starting point for further discussion on the feasibility and pros/cons. In that sense, we agree with that proposal. Similar discussion can be held for ***Opt. 2****: During Msg3 transmission* in the next step. |
| Lenovo, Motorola Mobility | Y |  |
| Nokia |  | Though we favour a msg1/msgA approach to enable the network to initially identify REDCAP devices, we have a similar view to OPPO. Let’s fairly downselect from proposal 2 first. |
| WILUS |  | We need to discuss all of options in proposal 2 at the same level. This proposal prioritizes option 1 in proposal 2.  |
| Xiaomi | Y |  |
| Spreadtrum |  | It may be too early to discuss this.  |
| Ericsson |  | Is the intention with the proposal to say that a potential approach for study is to leave it to the network to configure whether to use RedCap UE identification via Msg1/MsgA or whether to use RedCap UE identification later than Msg1/MsgA? In that case, we are fine with the proposal. If the intention is something else, then perhaps it is a premature proposal before we know more about what UE complexity reduction techniques (if any) that will be recommended by RAN1.Moderator: Yes, that is indeed the intention of the proposal (“*leave it to the network to configure whether to use RedCap UE identification via Msg1/MsgA or whether to use RedCap UE identification later than Msg1/MsgA”*)! |
| Apple  |  | We think it goes a bit far at this stage especially considering the dependency with Option.1. We may first progress on FL proposal 2 and further progress on this 2nd level details if Option.1 is selected.  |

## Summary (FL Prop 3):

* The group seems divided on FL Proposal 3 with many thinking that it may be “too early” to discuss this.
* Some companies see this as implying prioritization of Option 1 from FL Proposal 2.
	+ *This was not the intention; see next response below.*
* Another observation made by several companies is that Msg3 and MsgA-PUSCH should also be considered in the same light.
	+ *The proposal was based on views expressed in company contributions, wherein examples involving UE identification during Msg1 transmission have been cited. However, technically, such configurability can also be envisioned for Option 2 and MsgA-PUSCH.*

Considering the feedback above, FL Proposal 3 is revised as below, and should be interpreted as an extension of the study in FL Proposal 2A.

## FL Proposal 3A

* *Further study the configurability of methods for early identification of RedCap UEs:*
	+ *during Msg1/MsgA-PRACH transmissions,*
	+ *during Msg3/MsgA-PUSCH transmissions.*

# Analysis of options for UE identification

### During Msg1 transmission (Opt. 1)

**Feasibility**

Early identification of RedCap UE type during transmission of Msg1 can be achieved via one or more of:

* Separation of PRACH resources (occasions and/or formats) or PRACH preambles between RedCap and non-RedCap UEs
* Separation of initial UL BWP for RedCap and non-RedCap UEs.
	+ PRACH resource configuration may be separately or commonly provided for each initial UL BWP configuration

## Question 3.1.1-F(easability)

* *Are the above observations on feasibility of early identification of RedCap UE types during Msg1 transmission accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | gNB may configure a separate initial UL BWP for RedCap UE with PRACH resource configuration provided for the initial UL BWP. If this configuration is included in legacy SIB1 or new SIB1, gNB can identify RedCap UE via the initial UL BWP.  |
| CATT | Y | Agree in principle. But for the 2nd bullet, in our understanding, a RACH configuration belongs to a BWP configuration (e.g. each BWP-UplinkCommon contains one rach-ConfigCommon). In this case, PRACH resource configuration should be separately configured by natural. If a gNB configures the same PRACH resource in these two (new and legacy) UL initial BWP, it is by implementation and is another story. So we think ‘or commonly’ in the sub-bullet of 2nd bullet, or the whole sub-bullet of 2nd bullet can be removed, at least for the current stage. |
| Spreadtrum | Y |  |
| vivo |  | It may be only feasible to differentiate Redcap and non-redcap UEs, i.e. 1bit information. However, it may not be a good idea to further differentiate different RedCap UEs with different set of feature set combinations (e.g. processing timeline reduction, reduced Rx, reduced BW, relaxed modulation order, etc.) which has big impact to the PRACH resource partition.  |
| Huawei, HiSi02 | Y and | Share some view with vivo and according to RAN2 discussion, RedCap UE type is mainly used for differentiation of RedCap UE and non-RedCap UE.  |
| ZTE | Y | Agree in principle.The sub-bullet of 2nd bullet needs clarification. If separation of initial UL BWP for RedCap and non-RedCap UEs is used, then PRACH resources for RedCap UEs is separated accordingly. |
| Xiaomi |  | We are not sure whether the second bullet could achieve the purpose of early indication in some cases. For example, although different UL BWP is configured, these two UL BWP may overlap with each other and the share the same PRACH resource and same preamble. In this case, it is difficult to differentiate the Redcap devices and the non-Redcap devices. So to avoid the situation above, maybe further clarification or modification is needed for the second bullet. E.g., fully overlapping in the PRACH resource and preamble should be avoided.  |
| Nokia, NSB | Y | Agree in principal, though like others, would like some clarification of the 2nd bullet. |
| Futurewei | Ok in principle | The proposal could work with only the first bullet. The second bullet (use of a different UL BWP) is actually a means to implement the first bullet, and should be left for discussion during the WI phase |
| Qualcomm | Partially Y | We agree with the first bullet in principle. For the second bullet, we share similar views as Xiaomi, Futurewei and other companies.  |
| Panasonic | Y in principle | In the 1st bullet, separation of PRACH resources may also consider frequency domain. So in the bracket, frequency locations is proposed to be added like (frequency locations and/or occasions and/or formats).Also agree with VIVO and Huawei that the UE type identification is just for non-RedCap and RedCap. |
| Convida | Y |  |
| Ericsson | Y, partially | We share a similar view as CATT, i.e. that we prefer to delete “or commonly”, or to delete the entire sub-bullet, or to even delete the second main bullet altogether as suggested by Futurewei. |

**Necessity**

Early identification of RedCap UE type during transmission of Msg1 could be necessary in the following events:

* Relaxation of UE minimum processing times for PDSCH processing and PUSCH preparation
	+ *Strictly necessary? - No; gNodeB may need to schedule conservatively, always assuming RedCap UE, at the expense of slower initial access procedure for non-RedCap UEs*
* Coverage recovery for one or more of Msg2, Msg3, or Msg4 scheduling or the associated PDCCH
	+ *Strictly necessary? - Depends on outcome of discussion in AI 8.6.3 on Coverage Recovery and if Msg2 and/or Msg3 and/or broadcast PDCCH are identified as requiring coverage recovery.*
* Appropriate link adaptation for Msg2/Msg4 PDSCH or Msg3 PUSCH, and associated PDCCH
	+ *Strictly necessary? – No; gNodeB may need to schedule conservatively, i.e., always assuming RedCap UE, at the expense of increased system OH (from using conservative link adaptation even for non-RedCap UEs).*

## Question 3.1.1-N(ecessity)

* *Are the above observations on necessity of early identification of RedCap UE types during Msg1 transmission accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | Regarding processing time relaxation, we have no consensus on how much RedCap UEs relax UE minimum processing times during RACH procedure. Thus, it seems too early to say that gNodeB can always schedule conservatively assuming RedCap UEs by sacrificing non-RedCap UEs. We do not know how much non-RedCap UEs should sacrifice themselves at a cell where RedCap UEs may access.Regarding coverage recovery, it would depends on outcome of discussion in AI 8.6.3 on Coverage Recovery as indicated by FL.Regarding link adaptation, it is unclear whether gNB can always schedule conservatively assuming RedCap UEs. |
| CATT |  | Not really. For the current proposed events:1. For relaxed UE processing time: we have not agreed relaxed UE processing time for RedCap UE yet.
2. For coverage recovery: maybe, and agree with FL that we should wait for the outcome of AI8.6.3.
3. For link adaptation: agree with FL, not strictly necessary.

To our understanding, necessity of during Msg1 transmission may due to:1. Msg3 transmission with a bandwidth/hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP.

Other necessity reasons may include:1. PUCCH(ACK to Msg4) transmission with a hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP (but also valid for identification by Msg3)
2. PUSCH/PUCCH transmission after PUCCH(ACK to Msg4) and before RRC setup with a frequency resource larger than maximum RedCap bandwidth in the shared UL initial BWP (but also valid for identification by Msg3)
 |
| Spreadtrum | Y | Regarding processing time relaxation and link adaptation, the system performance will be degraded if gNodeB always assumes RedCap UE. |
| vivo |  | For “Relaxation of UE minimum processing times”, besides conservative scheduling, we may also consider to only allow relaxation of UE minimum processing time for large resource allocation or TBS so that UE can use Cap#1 processing time during initial access, since the PDSCH/PUSCH TB during initial access are typically small.About “Coverage recovery for one or more of Msg2, Msg3, or Msg4 scheduling or the associated PDCCH”, yes, first we need to wait the conclusion made in coverage AI. But even if the coverage recovery is needed for Msg2, Msg3, or Msg4, it is not specific for RedCap, the mechanism developed in Rel-17 Coverage SI can be reused here, it is not for differentiation between RedCap and non-RedCap UE, it is for differentiation of UEs requiring the coverage recovery .For “Appropriate link adaptation for Msg2/Msg4 PDSCH or Msg3 PUSCH”, we are wondering if the link adaptation here refers to the MCS selection (RedCap UE may not support high MCS), or BW reduction (RedCap UE only support 20MHz). For the MCS selection, we think it make sense for gNB to schedule conservative MCS during initial access before accurate CSI feedback is available. For BW reduction, our understanding is that the typically the network schedules UE within CORSET#0 BW (typically 20MHz which is one of the key reason that RedCap UE should support at least 20MHz) during initial access procedure, and the reconfigured (larger) initial BWP only applicable after MSG 4, see the following from 38.331. Therefore, we agree with FL assessment it is not essentially necessary.

|  |
| --- |
| ***initialDownlinkBWP***The initial downlink BWP configuration for a SpCell (PCell of MCG or SCG). The network configures the *locationAndBandwidth* so that the initial downlink BWP contains the entire CORESET#0 of this serving cell in the frequency domain. The UE applies the *locationAndBandwidth* upon reception of this field (e.g. to determine the frequency position of signals described in relation to this *locationAndBandwidth*) but it may keep the bandwidth of CORESET#0 until after reception of *RRCSetup*/*RRCResume/RRCReestablishment*. |

More importantly the feature set combinations(processing timeline reduction, reduced Rx, reduced BW, relaxed modulation order) that supported can be different across RedCap UEs targeting different use cases, therefore the number of sets of combinations can be large. It is not clear about the feasibility to use MSG1 to differentiate different set of RedCap UEs.  |
| Huawei, HiSi02 | Partially | Thanks for the FL’s nice analysis. Since the proposal is to say ‘could be’ we feel the sub-bullets generally look Ok but one thing we share with CATT is the UL initial BWP (needing hopping within 20Mhz for example). What is the plan for the sub-sub-bullets? |
| ZTE |  | For coverage recovery, we agree with FL that we should wait for the outcome of AI8.6.3. If coverage recovery is required for RAR or Msg3 transmission for RedCap UEs, identification of RedCap UEs during Msg1 transmission is necessary.We agree with CATT that early identification by Msg1 is necessary if Msg3 transmission with a bandwidth/hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP. |
| Xiaomi |  | Generally, we think it is better to list all possible reasons to understand the necessity of using Msg.1 well. As commented by some companies, the listed reason may not valid since currently there is no concrete agreement or conclusion. To address this concern, maybe some pre-condition can be added in the description, for example, if the relaxed processing time for redcap is agreed and would result in different transmission or receiving behaviors, then early indication in Msg.1 would be necessary. As for the detailed reasons, We are OK with the first and second reasons listed by the FL, maybe some pre-condition description is needed for these two reasons. For the third bullet, we don’t think it is necessary. Furthermore, the other reasons listed by CATT seems OKBesides the reason listed by CATT, maybe relaxed UL modulation order (e.g., 16 QAM in UL) can be another reason.  |
| Nokia, NSB |  | For relaxed UE processing time, we have not agreed relaxed UE processing time for RedCap UE yet.For coverage recovery, agree with others, this is pending the outcome of AI8.6.3.For link adaptation, would like to confirm if the current non-REDCAP “conservative” link adaption scheduling options are sufficient for all REDCAP “types”. |
| Futurewei | Y | For second bullet, we suggest the following wording modification: • Coverage recovery (including link adaptation) for one or more of Msg2, Msg3, or Msg4 scheduling or the associated PDCCH * *Strictly necessary? - Depends on outcome of discussion in AI 8.6.3 on Coverage Recovery and if Msg2 and/or Msg3 and/or broadcast PDCCH are identified as requiring coverage recovery.*

Note here that the intent is different from bullet 3: coverage recovery may require some type of link adaptation (e.g., repetition, different MC table, etc.), whereas bullet 3 addresses spectral efficiency concerns |
| Qualcomm |  | In our opinion, coverage recovery for control/data channels during initial access is a major motivation to introduce early identification of RedCap UE type. We don’t think it is necessary to include the following bullets:* “Relaxation of UE minimum processing times for PDSCH processing and PUSCH preparation”
* “Appropriate link adaptation for Msg2/Msg4 PDSCH or Msg3 PUSCH, and associated PDCCH”

There is no consensus on the relaxation of UE processing time for R17 RedCap devices. Link adaptation typically requires UE-specific CSI reporting, which is beyond the main functionalities of msg1 and does not apply to broadcast PDCCH/PDSCH channels. |
| Panasonic |  | For the first bullet, the processing time relaxation has not been concluded. So the expense is not clear so far.Regarding the second bullet, agree that it depends on the agreement of the bottleneck channel.On the third bullet, we agree the observation. |
| Convida |  | For the first and third bullets, regarding the processing time relaxation and link adaptation, respectively, using conservative scheduling has negative effects on non-RedCap UEs. The SID clearly states that coexistence between RedCap UEs and non-RedCap UEs should be ensured, as shown below. Therefore, to what extent that conservative scheduling is acceptable could be questionable. At a certain point, it may become strictly necessary to identify the RedCap UEs in Msg1.Excerpt from SID: “Note3: Coexistence with Rel-15 and Rel-16 UE should be ensured”For the second bullet, regarding the coverage enhancement, we agree that it depends on outcome of AI 8.6.3. |
| Ericsson |  | Regarding the first bullet, i.e.:* Relaxation of UE minimum processing times for PDSCH processing and PUSCH preparation
	+ *Strictly necessary? - No; gNodeB may need to schedule conservatively, always assuming RedCap UE, at the expense of slower initial access procedure for non-RedCap UEs*

…is it correctly understood that the above may only be an issue if the time between Msg2 and Msg3 (or the time between PDCCH and PUSCH for potential Msg3 retransmissions) is affected by the relaxed processing time? In that case, perhaps it should be clarified in the sub-bullet. In any case, this potential issue should only become relevant if RAN1 recommends introducing relaxed processing time.We also agree with CATT that Msg3 and PUCCH for Msg4 ACK can be added as possible motivations for early identification of RedCap UE type in Msg1. But we do not think these motivations give strict necessity for identifying RedCap UEs in Msg1 as there are other potential solutions to address these issues. |

**Pros and Cons**

Early identification of RedCap UE type during transmission of Msg1

|  |  |
| --- | --- |
| Pros | Cons |
| Enables efficient handling of different UE minimum processing times between RedCap and non-RedCap UEs for: minimum timing between PDSCH carrying RAR and start of Msg3 PUSCH; minimum timing between PDSCH carrying Ms4 and the corresponding HARQ-ACK feedback; minimum timing between PDCCH with the reTx grant and the corresponding Msg3 PUSCH retransmission.  | Reduction in PRACH user capacity (for the options based on separation of PRACH preambles), impacting both RedCap and non-RedCap UEs. |
| Enables coverage recovery for any one or more of: broadcast PDCCH, PDSCH associated with Msg2, PDSCH associated with Msg4, and PUSCH associated with Msg3, if coverage recovery is needed for these channels. | Increase in UL OH from PRACH (for the options based on separation of PRACH resources), impacting both RedCap and non-RedCap UEs. |
| Enables separate link adaptation for Msg2/Msg4 PDSCH and/or Msg3 PUSCH and/or their corresponding PDCCH between that for RedCap and non-RedCap UEs, and potentially, also between RedCap UEs with different numbers of DL Rx branches, etc. | Increase in UL OH and complexity in configuration and maintenance of multiple initial UL BWP for the gNodeB. |
| The option of configuring separate initial UL BWPs enables address congestion in the initial UL BWP that may otherwise need to be restricted to the mandatory required BW for RedCap UEs in the band/FR. | Scales poorly - the indication mechanisms in this category may be limiting in terms of distinguishing between further sub-categories within RedCap device type. |
|  | The option of configuring separate initial UL BWP is only available for FDD deployments and thus, may be limited in its effectiveness. |
|  | Higher impact to RAN1 and RAN2 specifications as well as increased SIB signaling OH compared to other options. |

## Question 3.1.1-P(ros&Cons)

* *Are the above observations on pros and cons for early identification of RedCap UE types during Msg1 transmission accurate and complete? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | Regarding ‘scales poorly’, it is not clear whether sub-categories within RedCap device type is really essential from RAN1 perspective. This aspect seems not a drawback depending on need for sub-categories.Regarding initial UL BWP, we think that for TDD, separate initial UL/DL BWP could be configured for RedCap UEs. Thus, this aspect seems not a drawback. |
| CATT | Y | Generally OK for us.For the pros, we think ‘configuring separate initial UL BWPs’ not only achieves the advantage in row4, but also achieves the benefit in row1~3. We think row4 of pros can be further modified as: **‘The option of configuring separate initial UL BWPs not only has the above pros but also enables address congestion in the initial UL BWP that may otherwise need to be restricted to the mandatory required BW for RedCap UEs in the band/FR.’** or something like this.For the cons, we agree with LG’s view. Additionally, row3 seems only for ‘configuring separate initial UL BWPs’, thus we suggest: ‘**Increase in UL OH and complexity in configuration and maintenance of multiple initial UL BWP for the gNodeB (for the option of configuring separate initial UL BWPs).’** |
| vivo |  | Regarding separate initial UL BWP for TDD, is the concern about different center frequencies between initial DL BWP and UL BWP from UE perspective? We think to make it work, more efficient way could be to allocate separate initial DL BWP for RedCap UEs as well, so as to keep the same center frequency between initial DL BWP and UL BWP for RedCap UEs.For MSG.2, if NW enables separate link adaptation for MSG.2 for redcap UEs, it may increase the overhead for DL in some cases, since due to the separate link adaptation, the NW may not be able to group the RAR for redcap UEs and redcap UEs in a single PDSCH. The overhead for RAR-PDCCH and RAR-PDSCH would be increased.For each claimed benefit, the assumption is that network should be able to correctly identify the feature combinations that is supported by RedCap UEs, as discussed before, it is not clear whether it is feasible to use MSG1 to differentiate RedCap UEs in such detailed granularity, as it will cause large overhead increase. Otherwise, if only 1bit information can be provided by MSG1, network has to treat all the RedCap UEs in the same way so that the claimed benefit will reduce.  |
| Huawei, HiSi02 |  | For the disadvantage of ‘reduction in PRACH user capacity’, actually, it is a common method to distinguish different UEs via PRACH preambles, e.g. MTC, EDT etc. Similarly, PRACH preamble partitioning can be used in RedCap.Perhaps the pros and cons in the table are not one to one mapped, correct? i.e., the first drawback is not due to the enabler for the first benefit. Similar to other rows. |
| ZTE |  | Regarding cons of ‘scales poorly’, we show similar view as LG. |
| Xiaomi  |  | For the cons listed in the first rows, it states the PRACH user capacity will be impacted. But we think the PRACH user capacity is the same compared with that in option 2, 3, 4. In the option of separate PRACH resource or preamble and the other options, if we assume the same total PRACH resource for all UEs including Redcap and non-Redcap, then the total number of supported user (including Redcap and non-Redcap) would be the same in theory. The only difference is that there is explicit partition in the PRACH resource or preamble for Redcap and non-Redcap in option 1 but in the other options, Redcap and non-Redcap share the same PRACH resource and preamble. But in all options, the maximum supported user would be the same.  As for the pros of separate PRACH resource or preamble, we think it would be more benefical to control the UE access and guarantee the initial access performance of the non-Redcap devices compared with option 2,3,4. For example, when there is a large number of Redcap devices in a cell, to avoid significant increase in preamble collision for non-Redcap devices , then less PRACH resource or preamble can be configured. But in option 2,3,4, Redcap devices and non-Redcap devices may share the same PRACH resource and preamble, then the preamble collision of non-Redcap devices may be out of control. Therefore, this point would be another pros for separation of PRACH resource or preamble |
| Nokia, NSB |  | Share the opinion with others regarding “scales poorly”/” reduction in PRACH user capacity’, depends a lot on the number of types of REDCAP we want to differentiate at this stage of access. Potentially (subject to coverage/framework discussions) this could be just one type, in which case, PRACH capacity may not be an issue.General comment:In our view, there is still an FFS regarding the use of msg1 and msg3 identification together, i.e. where Msg1 gives generic REDCAP differentiation and msg3 (subject to available bits) provides more detailed “sub-category” capability style information. Using a combination of techniques, may and may not, help alleviate some of the cons. |
| Futurewei |  | Removing the second bullet of 3.1.1-F would eliminate the “con” of the BWP.For the second pro, it should be coverage recovery (including link adaptation)We also would like to add the following pros:* for PRACH options that are well known from LTE
* the RACH preamble solution may allow smaller numbers or light traffic of RedCap with no additional overhead (which eliminates or at least mitigates the first con)

For the “scale poorly: "categories" is a loaded term, "distinguishing between different capabilities within RedCap UE type is better For the last pro (The option of configuring…): it is not clear at this stage that a congestion issue exists. Thus, we suggest adding “if it exists” after “congestion” |
| Qualcomm | N | This question is related to the answers/conclusions for “feasibility” and “necessity” of msg1-based early indication.For R17 RedCap devices, if there is no agreement on the “relaxation of UE processing time” and “configuration of separate initial UL BW,P” we don’t think it is necessary to comment further on their pros/cons associated with msg1-based early indication. |
| Panasonic |  | Similar view with LGE on ‘scales poorly’. Also, to identify the RedCap UE type by Msg1 may not allow gNB to identify the detailed RedCap UE type. Thus, due to different RedCap UE types are with possibly largely different reduced feature composition, it is not so easy for gNB to compensate and achieve the benefit of early detection. |
| Convida |  | If a separate initial UL BWP for RedCap UEs is introduced for TDD scenario, then it makes more sense to use a separate initial DL BWP for RedCap UEs as well with the same center frequency. This may simplify the RedCap implementation. Otherwise, RedCap UE needs to retune its oscillator for each step during the initial access.  |
| Ericsson |  | Regarding the 1st item in the Pros list (“Enables efficient handling of different UE minimum processing times”), it should be noted that it is only a relevant aspect if RAN1 recommends introduction of reduced processing times that affects Msg2 or Msg3.The 4th item in the Pros list (about initial UL BWPs) would also only be relevant if RAN1 recommends introduction of RedCap-specific initial UL BWPs.Another Pro that might be added to the list is that indication in Msg1 might simplify use of Msg3 frequency hopping for RedCap UEs, especially in scenarios where the initial UL BWP has wider bandwidth than the RedCap UE bandwidth.We suggest adding “increase gNB complexity” to the Cons list for the approach – “Separation of PRACH resources (occasions and/or formats)”. PRACH processing is one of the most demanding gNB signaling processing tasks. Perhaps, this can be added to the 3rd item in the list (“Increase in UL OH and complexity in configuration and maintenance of multiple initial UL BWP for the gNodeB”). Not just increasing the “complexity in configuration”, but also complexity in baseband signal processing.Another Con that can potentially be added in the 4th item in the list (“Scales poorly, etc.”) is that the issue with PRACH resource fragmentation could escalate even further if in the end not only RedCap UE indication but also Rel-17 Small Data feature related indication and perhaps even indications for combinations of these two features are via Msg1.Minor comment: there is a typo in the text – “Ms4” should have been “Msg4” |

### During Msg3 transmission (Opt. 2)

**Feasibility**

Early identification of RedCap UE type during transmission of Msg3 can be achieved via one or more of:

* Using the spare bit in existing Msg3 definition
* Defining a new TBS value for Msg3 PUSCH to carry additional one or more bits, indicating RedCap UE type

## Question 3.1.2-F

* *Are the above observations on feasibility of early identification of RedCap UE types during Msg3 transmission? accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | The feasibility of spare bit should be studied in RAN2, not in RAN1.  |
| CATT | Y | We agree with LG, but since it is very straightforward to use the spare bit, we think it is OK to mention. May be we can add a note ‘The feasibility should be further discussed in RAN2’ for the 1st bullet. |
| Spreadtrum |  |  Should be studied in RAN2. |
| vivo |  | Agree with LG that the available spare bit in MSG3 should be determined by RAN2. In addition, the feasbility of introducing new MSG3 message format should also be evaluated by RAN2. Based on the number of available bits, it may or may not be feasible to differentiate RedCap UEs with different feature set combinations.  |
| Huawei, HiSi02 | FFS | Only one bit is available in msg3 payload, the feasibility for using the spare bit is unclear. So indeed need to study the feasibility with RAN2. |
| ZTE |  | Should be studied in RAN2. |
| Xiaomi |  | Same view with LG |
| Nokia, NSB |  | Should be studied in RAN2. |
| Futurewei | OK in principle | In line with our comment for 3.1.1-F, our preference is to mention that the Msg 3 identification can be performed and to leave how to do it for the WI phase, thus removing the two sub-bullets.In addition, a note should be added that this is contingent on the CE part of the work, and that it can be done only if CE is not needed for Msg2 |
| Qualcomm |  | We have concerns on the feasibility of msg3-based early indication of RedCap UE type.In the ongoing discussion for coverage recovery, msg2 and msg3 are recognized as bottleneck channels for RedCap UEs. Therefore, the reliability of early indication cannot be ensured due to coverage limitation of msg3, and msg3 cannot help with the coverage improvement of msg2 as well. |
| Panasonic |  | The feasibility should be studied by RAN2 |
| Convida |  | The mentioned bullets should be studied in RAN2. From RAN1 perspective, we may have solutions like piggybacked UCI on Msg3 that can carry such indication in addition to other information such as CSI reports for the scheduling of the subsequent messages.  |
| Ericsson | Y | Should be studied in RAN2. |

**Necessity**

Early identification of RedCap UE type during transmission of Msg3 could be necessary in the following events:

* Coverage recovery for one or more of Msg4 PDSCH
	+ *Strictly necessary? - Depends on outcome of discussion in AI 8.6.3 on Coverage Recovery if Msg4 are identified as requiring coverage recovery.*
* Appropriate link adaptation for Msg2/Msg4 PDSCH or Msg3 PUSCH, and associated PDCCH
	+ *Strictly necessary? – No; gNodeB may need to schedule conservatively, i.e., always assuming RedCap UE, at the expense of increased system OH (from using conservative link adaptation even for non-RedCap UEs).*

## Question 3.1.2-N

* *Are the above observations on necessity of early identification of RedCap UE types during Msg3 transmission accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | If early identification is included in an additional bit of Msg 3, it would be in a RRC message. If it is the case, we wonder if gNB-DU should always decode this indication because gNB-DU does not have RRC. Meanwhile, Msg4 UE Contention Resolution Identity MAC CE is created by gNB-DU. gNB-DU may send Msg4 PDSCH without detecting early identification. Regarding link adaptation, it is unclear whether gNB can always schedule conservatively assuming RedCap UEs. |
| CATT |  | Similar comments in Question 3.1.1-N.For Msg3 identification, necessity may be caused by:1. PUCCH(ACK to Msg4) transmission with a hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP

Other necessity reasons may include:1. PUSCH/PUCCH transmission after PUCCH(ACK to Msg4) and before RRC setup with a frequency resource larger than maximum RedCap bandwidth in the shared UL initial BWP (but also addressed by Msg1 identification)

However, it cannot address the issue when Msg3 is scheduled with a bandwidth/hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP. |
| vivo |  | The same comments to Question 3.1.1-N should still apply here.  |
| ZTE |  | From coverage recovery point of view, identification by Msg3 is necessary only when Msg2/Msg3 coverage recovery is not needed but coverage recovery of Msg4 is needed. |
| Xiaomi |  | The second bullet is not necessary.  |
| Nokia, NSB |  | Similar comments to Question 3.1.1-N |
| Futurewei |  | Add “(including link adaptation)” after coverage recovery (see previous comment) |
| Qualcomm |  | Msg3-based early indication cannot help with link adaptation of msg2 or msg3 at all.  |
| Panasonic |  | Okay on the first bullet. Second bullet is not so clear why needed here. UE type identification by Msg3 will not help on link adaptation of Msg2 and Msg3. |
| Convida |  | We agree with the first bullet on whether the coverage of Msg4 PDSCH needs to be enhanced or not. We may also add the PDCCH that schedules Msg4 and the subsequent PUCCH that carries Ack of Msg4. However, in the second bullet, it’s not clear how identification in Msg3 can assist the link adaptation of Msg2. If the assumption here is that Msg2 is received correctly and the identification of RedCap is transmitted in Msg3, then the link adaptation should be used for subsequent messages, e.g., Msg4. We would like to clarify how early identification in Msg3 could enable link adaptation for Msg2 transmission. |
| Ericsson |  | Both bullets should list Msg4 PDSCH (and associated PDCCH and PUCCH) and Msg5 PUSCH (and associated PDCCH). Perhaps the two bullets can be merged into one.If RAN1 recommends relaxed processing time for RedCap UEs and the relaxed processing time affects the timing relationships for Msg3/4/5-related transmissions, then indication in Msg3 (or earlier) may potentially be necessary. |

**Pros and Cons**

Early identification of RedCap UE type during transmission of Msg3

|  |  |
| --- | --- |
| Pros | Cons |
| Enables coverage recovery for PDSCH associated with Msg4 (and scheduling of Msg5), if coverage recovery is needed for these channels. | If new TBS for Msg3 is not defined, this would consume the single spare bit currently available in Msg3 payload, and this may not be most desirable. |
| Enables separate link adaptation for Msg4 PDSCH between that for RedCap and non-RedCap UEs, and potentially, also between RedCap UEs with different numbers of DL Rx branches, etc. | If new TBS for Msg3 PUSCH is defined, additional mechanisms are likely necessary to allow UE to use a particular Msg3 PUSCH TBS (and/or resource allocation) in response to a RAR, and associated blind decoding by the gNB on the Msg3 PUSCH TBS (and/or resource allocation). Considerable impact to RAN1 and RAN2 specifications related to Msg3 scheduling and transmission. |
| Limited impact to RAN1 specifications if the spare bit in Msg3 payload is utilized. | The option of using the spare bit in Msg3 scales poorly - limiting to a single-bit indication may not be sufficient if intending to distinguish between further sub-categories within RedCap device type. |
| The option of new TBS for Msg3 PUSCH may offer good scalability in the number of bits for such UE identification; e.g., if sub-categories of RedCap device types are to be indicated in Msg3. | Cannot facilitate additional coverage recovery (if needed) or separate link adaptation for broadcast PDCCH and/or Msg2 PDSCH, and/or Msg3 PUSCH for RedCap UEs. |
|  | If UE minimum processing times are relaxed, cannot facilitate scheduling with separate minimum timing relationships for RedCap UEs (compared to non-RedCap UEs) between PDSCH carrying RAR and start of Msg3 PUSCH; minimum timing between PDSCH carrying Ms4 and the corresponding HARQ-ACK feedback; minimum timing between PDCCH with the reTx grant and the corresponding Msg3 PUSCH retransmission. This could result in increased initial access latency for non-RedCap UEs. |

## Question 3.1.2-P

* *Are the above observations on pros and cons for early identification of RedCap UE types during Msg3 transmission accurate and complete? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | Regarding Msg4, if early identification is included in an additional bit of Msg 3, it would be in a RRC message. If it is the case, gNB-DU may send Msg4 PDSCH without detecting early identification as we explained in 3.1.2-N. Accordingly, Msg3 could not be used to enable coverage recovery and separate link adaptation for PDSCH associated with Msg4.Regarding RAN1 impact, it is not clear whether RAN1 impact is limited until RAN2 confirms that a spare bit can be utilized. |
| CATT |  | For the pros, we have not agreed introducing sub-category yet.For the cons, additionally, this does not address the issue when Msg3 is scheduled with a bandwidth/hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP. |
| vivo |  | Cons for RAN1: Degraded MSG.3 performance due to potential larger TBS.Cons for RAN2: non-trivial RAN2 spec impact if new MSG 3 format is to be introduced to carry more information bits for early indication.  |
| ZTE |  | For the cons, we agree with CATT that this does not address the issue when Msg3 is scheduled with a bandwidth/hopping range larger than maximum RedCap bandwidth in the shared UL initial BWP. |
| Nokia, NSB |  | In general, we agree with the pros and cons. |
| Futurewei |  | In our view, the con “cannot facilitate additional coverage recovery” should be listed first since it is by far the most significant one. In addition, in this con, it can be added that the system may have to be very conservative especially with regards to the BW used (or could be listed as separate con, if preferred)Pro: “the option of new TBS…”: replace sub-categories by RedCap UE capabilities, as explained before |
| Qualcomm |  | Please see our comments on 3.1.2-F. |
| Panasonic |  | Agree with LGE. |
| Convida |  | One cons for UE identification in Msg3 is that gNB needs to use conservative scheduling when providing the grant for Msg3 transmission because the type of UE is not identified yet by gNB. This could have impact on non-RedCap UE. |
| Ericsson |  | The first two issues in the Pros list should mention Msg4 PDSCH (and associated PDCCH and PUCCH) and Msg5 PUSCH (and associated PDCCH). Perhaps the two issues can be merged into one.Issue 4 in the Cons list could also mention PDCCH for Msg3 retransmission.Agree with CATT/ZTE that this does not address issue of Msg3 scheduled with a bandwidth/hopping range larger than maximum RedCap bandwidth.Minor comment: typo in the text - “Ms4” should have been “Msg4”. |

### During Msg5 transmission or in UE capability report (Opt. 3)

**Feasibility**

Identification of RedCap UE type during transmission of Msg5 or as part of UE capability reporting are feasible from RAN1 perspective, with the indication being carried by the PUSCH. The key details pertain to RAN WG2.

## Question 3.1.3-F

* *Are the above observations on feasibility of identification of RedCap UE types during Msg5 transmission or in UE capability report accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| CATT | Y |  |
| Spreadtrum | Y |  |
| vivo | Y |  |
| ZTE | Y |  |
| Xiaomi | Y |  |
| Nokia, NSB | Y |  |
| Futurewei | Y | Add a comment that depends if CE is needed for messages before Msg5 |
| Qualcomm |  | It is unclear to us what the feasibility is about for opt.3. Is it determined by coverage or other criteria ? If UE is able to identify itself as a RedCap device type before msg5 transmission, shall RAN1 discuss additional means of UE type identification ? |
| Panasonic | Y |  |
| Convida | Y |  |
| Ericsson | Y |  |

**Necessity**

The options of RedCap UE identification during Msg5 transmission or in the UE capability report would be essential if earlier identification is not supported/configured.

From the perspective of RAN1, there is no functional difference between the options of UE identification during Msg5 transmission and in UE capability report.

Note that depending on exact definition and types of RedCap devices, some or all information regarding RedCap UE identification may be provided as part of UE capability reporting, irrespective of whether early indication of RedCap UE type is also provided during Msg1 or Msg3 transmission.

## Question 3.1.3-N

* *Are the above observations on necessity of identification of RedCap UE types during Msg5 transmission or in UE capability report accurate and agreeable? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG |  | RAN1 may need to focus on whether identification earlier than Msg5 is necessary or not. Necessity of RedCap UE identification during Msg5 transmission could be discussed in RAN2 later.  |
| CATT | Y | Necessity of Msg5 may include ‘how to restrict the RedCap UE within the intended use case’; however, it is from RAN2/SA2 perspective.  |
| Spreadtrum | N | RedCap UE will support the identification in the UE capability report naturally. In our opinion, it is not necessary to indicate the UE type in Msg 5. If the UE capabilities are already in the AMF, the gNB retrieves the UE capabilities from the AMF after receiving Msg5 when the UE enters RRC CONNECTED mode from RRC IDLE mode, and the gNB retrieves the UE capabilities after receiving Msg3 when the UE enters RRC CONNECTED mode from RRC INACTIVE mode. It is too late and not necessary any more for UE identification in Msg5. |
| vivo |  | Agree with LG. Based on the discussion in last GTW session, our understanding is that RAN1 should focus on the necessity and feasibility of early indication by MSG1 or MSG3.  |
| Huawei, HiSi02 | FFS | It is not clear why it is feasible. From the perspective of carrying RedCap related information by Msg5 it is feasible. However there seems to be issue with e.g. at least reduced BW size will not be assumed as initial UL BWP. |
| ZTE |  | RAN2 scope |
| Xiaomi |  | Same view with LG |
| Nokia, NSB |  | Same view as LG |
| Futurewei | Y |  |
| Qualcomm |  | We think it is necessary to clarify if there is any overlapping of UE capability report based on opt.1, opt.2 or opt.3.Besides, we share the same views as LG and other companies that RAN1 should focus on the feasibility study for early indication of RedCap UE type. |
| Panasonic | Y in general | Also agree with LGE that RAN2 should cover this. |
| Ericsson |  | Agree with LG |

**Pros and Cons**

Identification of RedCap UE type during transmission of Msg5 or in UE capability report

|  |  |
| --- | --- |
| Pros | Cons |
| At least the option of UE capability reporting offers the simplest and most scalable option for indication of RedCap UE type with full flexibility. | Cannot facilitate additional coverage recovery (if needed) or separate link adaptation for broadcast PDCCH and/or Msg2 and/or Msg4 PDSCH, and/or Msg3 PUSCH for RedCap UEs. Too conservative scheduling and link adaptation for all UEs imply increased system OH for initial access in the initial DL and UL BWPs. |
| Limited or no impact to RAN1 specifications. | If UE minimum processing times are relaxed, cannot facilitate scheduling with separate minimum timing relationships for RedCap UEs between PDSCH carrying RAR and start of Msg3 PUSCH; minimum timing between PDSCH carrying Ms4 and the corresponding HARQ-ACK feedback; minimum timing between PDCCH with the reTx grant and the corresponding Msg3 PUSCH retransmission. This could result in increased initial access latency for non-RedCap UEs. |
|  |  |

## Question 3.1.3-P

* *Are the above observations on pros and cons for early identification of RedCap UE types during Msg5 transmission or in UE capability report accurate and complete? Please share your views, including any further considerations, below.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y |  |
| CATT | Y | For the cons, can also add ‘Cannot address the issue where Msg3/PUCCH to Msg4/Msg5 is scheduled with a bandwidth/hopping range larger than the maximum RedCap UE bandwidth in the shared UL initial BWP’. |
| Spreadtrum | Y |  |
| vivo |  | Based on the discussion in last GTW session, our understanding is that RAN1 should focus on the necessity and feasibility of early indication by MSG1 or MSG3. |
| ZTE | Y |  |
| Nokia, NSB | Y |  |
| Futurewei | Y | We suggest to use the wording “RedCap UE type/capabilities” instead of RedCap UE types |
| Qualcomm | FFS |  |
| Panasonic | Y |  |
| Ericsson |  | Agree with CATT. Some of the cons listed for the “Msg3” option are also relevant for this option.The issues in the Cons list could also mention the PDCCH transmission related to Msg3 retransmission, PDCCH and PUCCH transmissions related to Msg4, and PDCCH and PUSCH transmissions related to Msg5.Minor comment: typo in the text - “Ms4” should have been “Msg4”. |

### During MsgA transmission (Opt. 4)

This set of options include:

* During MsgA-PRACH transmission
* During MsgA-PUSCH transmission

In general, most of the observations for Msg1 and Msg3 may apply to the options involving MsgA-PRACH and MsgA-PUSCH respectively, except that there may not be any difference between the MsgA-PRACH and MsgA-PUSCH options in terms of UE identification for scheduling of PDCCH and PDSCH for MsgB.

Other details for MsgA to be added further when the discussions in the previous sub-sections for Options 1 through 3 are a bit more stable.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | Option 4 could be discussed later after down-selecting to one of Option 1, 2 and 3. |
| vivo | Agree to discuss Msg.A after option 1 is more stable. In addition, we are not sure whether 2-Step RACH will be typically supported by RedCap UEs, if not, then solutions based 2-step RACH seems not that helpful.  |
| Huawei, HiSi02 | MsgA may have a benefit of eliminating the need of differentiation of doubled processing time during initial access and coverage recovery (2step RACH is supposed to be used in good coverage and small packet) for Msg3. But we are ok to look into it later. |
| ZTE | To discuss MsgA after Option 1 is selected |
| Xiaomi | It is not urgent to discuss this option. If option1 is adopted, we could start the discussion.  |
| Nokia, NSB | Postpone discussion until option 1 discussion is concluded. |
| Qualcomm | We should prioritize the discussions for Opt.1 and Opt.2. |
| Panasonic | Can be FFS later after 4-step RACH procedure is concluded. |
| Convida | We agree. The discussions on how Opt. 1 (during Msg1) and Opt. 2 (during Msg3) could be used to identify the RedCap UE can be the baseline for MsgA. |

# RRM relaxations for UE power savings

In contributions [4] and [13], views on RRM relaxations for RedCap UEs that may be stationary to enable reduced power consumption have been presented (see Appendix B for summary of proposals).

Following the earlier conclusion from RAN1 #102-e meeting (see below), it is recommended that these discussions be deprioritized until RAN WG2 makes further progress.

From RAN1 #102-e [29]:

|  |
| --- |
| **Conclusion:*** *RAN1 to defer to RAN2 for further progress on studies regarding RRM relaxations and E-DRx for RedCap UEs to facilitate reduced UE power consumption.*
 |

# References

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1. R1-2007533, UE identification and access restriction for RedCap Ericsson
2. [R1-2007538](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007538.zip), Identification for RedCap UEs FUTUREWEI

1. R1-2007672, RRM relaxation for Reduced Capability NR devices vivo, Guangdong Genius

1. R1-2007719, Access control and identification for Reduced Capability NR devices ZTE

1. R1-2007866, Identification and access restriction for reduced capability NR devices CATT
2. [R1-2007951](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007951.zip), On identification of and access control for RedCap UEs Intel Corporation
3. [R1-2008020](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008020.zip), Discussion on identification and access control for Reduced Capability NR devices CMCC

1. R1-2008052, Other aspects for reduced capability NR devices LG Electronics

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2. [R1-2008075](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008075.zip), Procedure of identification for Reduced Capability NR devices TCL Communication Ltd.
3. [R1-2008088](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008088.zip), Discussion on the access control and configuration for reduced capability device Xiaomi

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2. [R1-2008174](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008174.zip), UE identification and access barring Samsung
3. [R1-2008264](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008264.zip), Other considerations for reduced UE capability OPPO
4. [R1-2008291](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008291.zip), On RedCap device identification Panasonic

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2. [R1-2008556](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008556.zip), Discussion on UE identification for RedCap NTT DOCOMO, INC.
3. [R1-2008585](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008585.zip), Discussion on identification of reduced capability UE ASUSTeK
4. [R1-2008688](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008688.zip), Device identification and access restriction for RedCap InterDigital, Inc.
5. [R1-2007671](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007671.zip), Framework and Principles for Reduced Capability vivo, Guangdong Genius *(from AI 8.6.4)*
6. [R1-2008087](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008087.zip), Framework and Principles for Reduced Capability Xiaomi
7. [R1-2008101](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008101.zip), Discussion on Framework and Principles for Reduced Capability Spreadtrum Communications
8. [R1-2008296](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008296.zip), Framework and Principles for RedCap Lenovo, Motorola Mobility
9. [R1-2008513](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008513.zip), On the framework for RedCap UEs MediaTek Inc.
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11. R1-2007283, Summary on [102-e-NR-RedCap-05] Moderator (Intel Corporation), RAN1#102-e.

# Appendix A

**List of observations/proposals on access control for and identification of RedCap UEs:**

R1-2007533 UE identification and access restriction for RedCap Ericsson

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [Proposal 1 In the TR, capture feasibility/pros/cons for different options from RAN1 perspective, considering the input in the table in this contribution. Do not make further attempts to down-select between the options in this RAN1 meeting.](#_Toc53800340)

|  |  |
| --- | --- |
| **Option** | **Feasibility/pros/cons from RAN1 perspective** |
| Option 1: Msg1 | Feasibility:* Yes, assuming enough PRACH resources are available for grouping

Pros:* Msg2/3/4/5 transmission parameters can be optimized for RedCap and non-RedCap UEs, respectively
* Does not require any additional bits in Msg3 (from RAN1 perspective)

Cons:* Increased PRACH resource consumption/fragmentation; the fragmentation could multiply if Msg1 indication is further used for RedCap UE identification, Small Data transmission and slicing, possibly leading to resource depletion
 |
| Option 2: Msg3 | Feasibility:* Yes, assuming Msg2/3 transmission does not become an issue without earlier indication

Pros:* Msg4/5 transmission parameters can be optimized for RedCap and non-RedCap UEs, respectively
* No increased PRACH resource consumption/fragmentation

Cons:* Msg2/3 transmission parameters cannot simultaneously be optimized for RedCap and non-RedCap UEs
* Requires at least one bit in Msg3 and potentially a larger Msg3 TBS
 |
| Option 3: Msg5+ | Feasibility:* Yes, assuming Msg2/3/4/5 transmission does not become an issue without earlier indication

Pros:* No increased PRACH resource consumption/fragmentation
* Does not require any additional bits in Msg3 (from RAN1 perspective)

Cons:* Msg2/3/4/5 transmission parameters cannot simultaneously be optimized for RedCap and non-RedCap UEs
 |
| Option 4: MsgA | Feasibility:* Yes, assuming 2-step RACH is used

Pros:* MsgB and Msg5 transmission parameters can be optimized for RedCap and non-RedCap UEs, respectively
* Pros for UE indication in MsgA preamble part are similar as for Option 1
* Pros for UE indication in MsgA PUSCH part are similar as for Option 2

Cons:* Cons for UE indication in MsgA preamble part are similar as for Option 1
* Cons for UE indication in MsgA PUSCH part are similar as for Option 2
 |

Proposal 2 RAN1 continues to prioritize study of other aspects of the study item and leave the study of access restriction to RAN2. |

[R1-2007538](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007538.zip) Identification for RedCap UEs FUTUREWEI

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| --- |
| *Observation 1: it is better to pool RACH resources between RedCap and non-RedCap UEs.**Proposal 1: Similar to LTE-M, PRACH preamble partitioning is used for RedCap identification**Proposal 2: RedCap identification in Msg 3 can be considered if RAN1 decides that no compensation for coverage is needed for Msg 3**Proposal 3: If two-step RACH is supported, RedCap identification in Msg A can be considered* |

[R1-2007672](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007672.zip) RRM relaxation for Reduced Capability NR devices vivo, Guangdong Genius

|  |
| --- |
| Observation 1: IDLE mode power saving is critical for wearable devices.Observation 2: 13.4% power saving gain in IDLE mode can be observed if serving cell RRM relaxation is introduced for high SINR UE.Observation 3: It is feasible for RedCap UEs to process SSBs once per multiple paging cycles.Proposal 1: Serving cell RRM relaxation for high SINR UE in idle state should be supported for RedCap UE. |

[R1-2007719](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007719.zip) Access control and identification for Reduced Capability NR devices ZTE

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| *Observation 1: For reduced capability NR devices, an access control indication carried in DCI scheduling SIB1 is beneficial for UE’s power saving.**Observation 2: Early identification of RedCap UEs as early as possible is beneficial for coverage recovery and dedicated scheduling of messages during initial access.**Proposal 1: For reduced capability NR devices, an access control indication is carried in DCI scheduling SIB1.**Proposal 2: From RAN1 perspective, identification of RedCap UEs during Msg1/MsgA transmission is feasible.* |

[R1-2007866](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007866.zip) Identification and access restriction for reduced capability NR devices CATT

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| Observation 1: *cellBarred* in MIB already provides overall barring information, which is determined comprehensively from network perspective.Observation 2: the motivation of introducing RedCap-specific barring indication before acquiring SIB1 need further study.Observation 3: Redcap identification during Msg1 may benefit the scheduling of largest number of channels before RRC setup, at the cost of PRACH partitioning.Observation 4: Redcap identification during Msg3 may benefit the scheduling of small number of channels before RRC setup, at the cost of future Msg3 extendibility.Observation 5: Redcap identification after Msg4 is considerable, if the current RACH procedure can be reused for RedCap.Proposal1: Leave the access restriction of RedCap UE to RAN2 discussion |

[R1-2007951](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2007951.zip) On identification of and access control for RedCap UEs Intel Corporation

|  |
| --- |
| Observation 1:* *Identification of RedCap UEs at least after Msg4 Ack (i.e., via Msg5 or UE capability reporting) is necessary as a baseline mechanism.*

Observation 2:* *Early identification of RedCap UEs during RA procedure may not always be necessary. Such mechanisms, if introduced, could be optionally configured by the gNB via SIB signaling.*

Observation 3:* *Early identification of RedCap UEs via Msg1 or MsgA could be beneficial, although not strictly necessary, if relaxed minimum UE processing times are introduced for RedCap UEs.*

Observation 4:* *Early identification of RedCap UEs during the RA procedure may not be necessary from perspective of coverage recovery needs for Msg2 and/or Msg4.*

Observation 5:* *Early identification of RedCap UEs during RA procedure may be necessary if additional or separate initial DL or UL (respectively) BWPs may be configured for Msg2/Msg4 or Msg1/Msg3 (respectively).*
 |

[R1-2008020](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008020.zip) Discussion on identification and access control for Reduced Capability NR devices CMCC

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| --- |
| Proposal 1: Msg.3 can be used for early identification of RedCap UEs.Proposal 2: Separate initial BWP can be used for early identification of RedCap UEs.Proposal 3: Early access control by PBCH, type0-PDCCH, SIB1, PRACH procedure can be further studied. |

[R1-2008052](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008052.zip) Other aspects for reduced capability NR devices LG Electronics

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| Observation 1: It is beneficial to introduce a new SIB1 for REDCAP UEs e.g. for support of potential REDCAP specific common channel configuration and transmissions without any concern on SIB1 size.Proposal 1: Study a mechanism for scheduling new SIB1 (e.g. SIB1-R) used by REDCAP UEs.Observation 2: In LTE, MIB provides scheduling of SIB1-BR. However, it seems difficult for NR MIB to accommodate scheduling information of a new SIB1-R. Proposal 2: If CORESET0 can be shared by REDCAP UEs and normal UEs, the DCI format 1\_0 with CRC scrambled by SI-RNTI can be used to schedule both legacy SIB1 and new SIB1-R.Observation 3: If the DCI schedules new SIB1-R, REDCAP UEs can identify whether the cell supports REDCAP UEs based on the DCI.Proposal 3: The DCI format 1\_0 with CRC scrambled by SI-RNTI explicitly or implicitly indicates whether the cell supports REDCAP UEsObservation 4-1: gNB currently transmit other system information within the size of CORESET 0. However, REDCAP UEs may or may not receive legacy transmission of other system information depending on RAN1 discussion. In addition, gNB could possibly provide different configurations in other system information to REDCAP UEs and normal UEs.Observation 4-2: It is beneficial for gNB to know whether on-demand SI is requested by REDCAP UEs or normal UEs.Proposal 4: REDCAP specific RACH resources can be configured for gNB to transmit on-demand SI message decodable by REDCAP UEs. Observation 5: A best beam RS would not frequently change for a certain stationary UE for which some aspects could be optimized.Proposal 5: Study relaxed operation of RLM/BFD as well as RRM for a stationary UE.  |

[R1-2008072](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008072.zip) Initial access for RedCap UEs Nokia, Nokia Shanghai Bell

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| Observation 1: The NR MIB “cellBarred” bit applies to all UEs (RedCap and non-RedCap) attempting to access the cell.Observation 2: The NR MIB does not support enough spare bits to indicate RedCap device specific barring.Observation 3: The DCI format 1-0 variant used to schedule SIB1 and other SI messages has 15 reserved bits.Observation 4: The enhancement of UAC for REDCAP is pending SA1 discussions.Proposal 1: A REDCAP UE can determine if a cell supports REDCAP without the need to read SIB1.Proposal 2: A REDCAP UE can determine if a REDCAP capable cell is barring specific REDCAP capability types without the need to read SIB1.Note: This level of “hard” barring compliments the SIB1 based UAC level of “soft” barring.Proposal 3: RAN1 and RAN2 to determine if a separate SIB1 for REDCAP devices, R-SIB1, is specified.Proposal 4: If a separate R-SIB1 is specified for REDCAP devices, then a new DCI RNTI is defined to scramble a DCI that shares the same search space as used by the current SIB1 DCI, but which schedules the new R-SIB1.Proposal 5: If the current SIB1 is to be reused by REDCAP devices, then some of the reserved bits in the existing DCI used to schedule the SIB1 are used to indicate cell REDCAP capability.Proposal 6:         If RAN1 determines that additional coverage recovery is needed on msg2/msgB, the network can identify REDCAP UEs at the msg1/msgA stage (options 1 and 4) of the RACH procedures.                            FFS:  The specific method(s) of identification, preamble partitioning/separate UL BWP/etc |

[R1-2008075](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008075.zip) Procedure of identification for Reduced Capability NR devices TCL Communication Ltd.

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| Proposal 1: Study the methods to partition preambles to minimize the impact on the current specifications. Proposal 2: Study the method of identifying UE type by the location of PRACH occasionProposal 3: The specific identification of the reduced capability UE type post-RAR shall be considered.Proposal 4: Further study to determine which method to be adopted. |

[R1-2008088](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008088.zip) Discussion on the access control and configuration for reduced capability device Xiaomi

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| Proposal 1: Network access control to RedCap UE should be explicitly indicated as early as possible.Proposal 2: Mechanism for identification of RedCap UEs During Msg1 transmission should be supported.  |

[R1-2008106](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008106.zip) Consideration on power saving for reduced capability NR devices Spreadtrum Communications

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| *Proposal 1: RRM measurement relaxation for neighbour cells including frequency layers with higher/equal/lower priority can be considered for stationary RedCap UEs.**Proposal 2:* *RRM measurement relaxation for serving cell can be considered for stationary RedCap UEs.* |

[R1-2008174](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008174.zip) UE identification and access barring Samsung

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| Proposal #1: Support early access for identification for RedCap UEs during random access.  |

[R1-2008264](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008264.zip) Other considerations for reduced UE capability OPPO

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| *Observation: Identification of RedCap UEs by Msg1 will reduce the utilization efficiency of PRACH resource.**Proposal 1: Separate SSB and CORESET 0 are not used for cell barring indication.* *Proposal 2: Leagacy Access Control mechanism is reused for RedCap UE as much as possible. The details are discussed in RAN2.* *Proposal 3: Msg1 or Msg3 can be used for the identification of RedCap UE. Msg3 is slightly preferred.* |

[R1-2008291](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008291.zip) On RedCap device identification Panasonic

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| Observation 1: RedCap device type identification during Msg1 transmission allows network to compensate the coverage performance in early stage and the efficiency of Msg2 and larter could be improved. Observation 2: In general, it is feasible to support RedCap device type identification by configuring separate PRACH resource in SIB with some specification impact. Observation 3: Compared with separate PRACH resource in time and frequency domain, PRACH preamble partitioning may involve additional standardization efforts in RAN1 and lead to more complicated gNB implementation.Observation 4: It would be a challenge to PRACH resource and preamble capacity for UE identification via Msg1 if more than one UE types for RedCap need to be identified.Observation 5: Device type identification during Msg3 transmission is attractive when Msg1 resource is limited like narrower system bandwidth. There is no RAN1 specification impact.Observation 6: For device type identification during Msg3 transmission, the network is not able to compensate the coverage performance for Msg2 and Msg3. There could also be scheduling limitation for normal UEs, although it could be regarded as the acceptable cost compared with the resource overhead of Msg1 sharing to RedCap devices.Observation 7: The pros and cons for device type identification via Msg3 and post Msg4 transmission are quite similar. The more detailed differentiation of RedCap devices needs to use this option using the existing framework of UE capability reporting, if supported.Observation 8: Device type identification during MsgA transmission requires additional standardization efforts.Observation 9: The pros and cons for device type identification via MsgA is similar with that of Msg1 and Msg3, except earlier identification by MsgA than Msg3. |

[R1-2008329](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008329.zip) Other aspects for reduced capability devices Huawei, HiSilicon

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| *Observation 1: For FR1, spare bits in MIB are possible for restricting the access of RedCap UEs.**Observation 2*: *Compared with access restriction via SIB1, access restriction via DCI associated with SIB1 is beneficial for RedCap UE’s power saving and with minor specification impact.**Observation3: The earlier the network identify the RedCap UEs, the better for the gNB to separately schedule the data transmission and make network control on RedCap UEs.**Proposal 1: It is necessary for network to indicate its capability of whether it supports RedCap UEs accessing or not.**Proposal 2: Consider to restrict the access of RedCap UEs via DCI associated with SIB1.**Proposal 3: Consider to identify RedCap UEs via Msg1/MsgA.* |

[R1-2008337](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008337.zip) Narrowband operation and identification of RedCap UE Lenovo, Motorola Mobility

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| * **Proposal 1:** Specify a RedCap UE category(ies), each category defining a particular set of mandatory RedCap UE features and/or capabilities.
* **Proposal 2:** Support indication of a RedCap UE category based on active applications or traffic types.
* **Proposal 3:** For a reduced capability UE, support operating with a bandwidth smaller than a bandwidth of an active BWP.
* **Proposal 4:** Study mechanisms exploiting the frequency diversity and realizing interference randomization within an active BWP, for a case that a reduced capability UE operates with a bandwidth smaller than a bandwidth of the active BWP.
* **Proposal 5:** Support dynamic switching between narrowband and wideband operations within a BWP.
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[R1-2008397](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008397.zip) Identification and access restriction for reduced capability UEs Sharp

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| ***Proposal 1:*** *RedCap UEs are identified by Msg1 transmission.****Proposal 2:*** *Indication of whether a RedCap UE can camp on a cell, as already agreed in RAN2, is in SIB.****Observation 1:*** *The RedCap specific cell-barring indication in system information is only used when the “cellBarred” bit in MIB indicates “notBarred”.* |

[R1-2008556](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008556.zip) Discussion on UE identification for RedCap NTT DOCOMO, INC.

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| Observation 1: * It is beneficial to identify RedCap UEs through Msg1 so that gNB can schedule RedCap UEs appropriately using the coverage recovery techniques for Msg2/3/4
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[R1-2008585](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008585.zip) Discussion on identification of reduced capability UE ASUSTeK

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| Observation 1: There is a trade off in the base station whether it performs the coverage recovery technique when it has not identified the RedCap UE.Observation 2: RedCap UE may fail to decode RAR and Msg4 in Opt. 2 and Opt. 3 if the base station does not deploy the coverage recovery technique when it has not identified the RedCap UE.Proposal 1: Select Opt. 1, Opt. 4 as methods for identification of RedCap UE during random access procedure.Observation 3: Configuring a separated initial uplink bandwidth part of RedCap UE improves the load balance and removes the restriction on configuring the legacy initial uplink bandwidth part.Observation 4: Configuring separated RACH resource on time for RedCap UE may delay the downlink scheduling.Proposal 2: Consider configuring a separated initial uplink bandwidth of RedCap UE for identification in random access procedure. |

R1-2008688 Device identification and access restriction for RedCap InterDigital, Inc.

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| Observation-1: Using Msg1/A for RedCap UE identification could avoid unnecessary PRACH collision increase for the other type of devices.Observation-2: With a limited number of PRACH resource configured for the RedCap UEs, the access could be restricted naturally.Observation-3: The use of Msg1/A for RedCap UE identification could be up to gNB configuration.Proposal 1: Support dedicated resources of Msg1/A for the RedCap UE identification and it is up to the network whether to configure the dedicated Msg1/A resources for RedCap UEs. |

**Proposals/observations relevant to access control and UE identification from AI 8.6.4:**

R1-2007671 Framework and Principles for Reduced Capability vivo, Guangdong Genius

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| Observation 2: repetitions for initial access channels are not specific for RedCap UEs, if coverage enhancements SI/WI decide the solutions for differentiating the UEs requiring repetitions and UEs not requiring repetitions, it is desirable to reuse the solutions. Proposal 4: further study following two options for identification of RedCap UEs:* Opt. 1: During Msg1 transmission via separate initial UL BWP.
* Opt. 5: During UE capability reporting.
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R1-2008087 Framework and Principles for Reduced Capability Xiaomi

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| Proposal 4: Early identification of RedCap capability by RACH procedure can be considered.  |

R1-2008101 Discussion on Framework and Principles for Reduced Capability Spreadtrum Communications

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| *Proposal 3: Study the early indication of RedCap UE capability or the solutions that can free the configuration of the uplink initial BWP of normal UEs from the limitation of the maximum bandwidth of RedCap UEs.* |

R1-2008296 Framework and Principles for RedCap Lenovo, Motorola Mobility

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| *Observation 3: The gNB could control the access of RedCap UEs in different stages during initial access, depending on different design.* *Proposal 3: Study the feasibility of UE access control during initial access, through** *Cellbarred in dedicated SSB*
* *Cellbarred introduced in SIB1*
* *RACH procedure*

*Proposal 4: Study UE type identification through either Msg1/MsgA or Msg3.* |

R1-2008513 On the framework for RedCap UEs MediaTek Inc.

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| 1. *A RedCap UE only camps on a cell that indicates support of RedCap operation.*
2. *Support of RedCap operation in a cell is broadcasted by the network.*
3. *A RedCap UE that is registered to a network is identified by the network at msg5.*
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[R1-2008623](file:///C%3A%5CUsers%5Cdchatt2%5COneDrive%20-%20Intel%20Corporation%5CDocuments%5Cwork%5C3gpp%5CRAN1%5CContribution%20reviews%5CRAN1_103E_contribution_review%5CallTdocs_R1-103e%5CR1-2008623.zip) Standardization Framework and Design Principles for RedCap Devices Qualcomm Incorporated

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| *Proposal 4: Support early indication of RedCap device type by Type-1 and Type-2 RACH procedures.* |

# Appendix B

**List of observations/proposals on RRM relaxations for RedCap UEs:**

R1-2007672 RRM relaxation for Reduced Capability NR devices vivo, Guangdong Genius

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| Observation 1: IDLE mode power saving is critical for wearable devices.Observation 2: 13.4% power saving gain in IDLE mode can be observed if serving cell RRM relaxation is introduced for high SINR UE.Observation 3: It is feasible for RedCap UEs to process SSBs once per multiple paging cycles.Proposal 1: Serving cell RRM relaxation for high SINR UE in idle state should be supported for RedCap UE. |

R1-2008106 Consideration on power saving for reduced capability NR devices Spreadtrum Communications

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| *Proposal 1: RRM measurement relaxation for neighbour cells including frequency layers with higher/equal/lower priority can be considered for stationary RedCap UEs.**Proposal 2:* *RRM measurement relaxation for serving cell can be considered for stationary RedCap UEs.* |