**3GPP TSG RAN WG1 Meeting #102-E R1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary on [102-e-NR-RedCap-05]**

**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 relevant contributions to AI 8.6.4, including RAN2-led issues.

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 and E-DRx for power savings

# 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].*

Considering potential adverse impact to system spectral efficiency in accommodating RedCap UEs, with reduced capabilities compared to regular NR UEs, it is deemed necessary to study mechanisms that allow the network to prevent RedCap UEs from accessing the network. Such may be realized in different ways, depending on exact scenario and use-case, etc.

In contributions [2], [4], [5], [8], [10], [12], [13], [14], [15], [16], [17], [18], [19], [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 access control for RedCap UEs.

Based on discussed options in company contributions, access control mechanisms can be categorized into three broad types:

* **Cell barring:** The cell does not support RedCap UEs, and thus, such UEs may not access or even camp on such cells.
  + May be realized via explicit (as few as a single bit) or implicit indication (via absence of configuration parameters or physical signal/channel configurations specific to RedCap UEs).
  + It has also observed in multiple contributions that it would be desirable to have such indication available to the UE at an early stage of initial access
  + Implicit or explicit signaling options mentioned in contributions include:
    - Via separate SSB and/or CORESET 0
    - Via indication in MIB
    - Via indication in DCI format scheduling SIB1
    - Via indication in SIB1
    - Via RACH procedure
  + It has also been pointed out that indication via MIB using the existing *cellBarred* field is not possible for specifically barring RedCap UEs as it impacts regular/legacy UEs as well. Multiple companies have also indicated that it may not be desirable to use up the single spare bit (for FR1) available in the MIB for such signaling.
* **Access barring:** This corresponds to temporary access control, e.g., for RedCap UEs as means of congestion control mechanism.
  + Multiple contributions note that the Unified Access Control (UAC) mechanism, defined in Rel-15 NR, should be reused. Furthermore, details of this may be pursued further in RAN2 than in RAN1.
* **Soft access barring:** Implicitly limiting access for RedCap UEs via controlling PRACH (re-)transmission opportunities, etc. via appropriate configuration of PRACH parameters for RedCap UEs.
  + Examples include, configuration of PRACH parameters, specific to RedCap UEs, that can help limit access opportunities for RedCap UEs. Such may be realized not only via separate configuration of PRACH resources for RedCap UEs, but also via limiting maximum number of PRACH attempts, or via configuring longer back-off times for RedCap UEs.
  + This approach relates to the issue of identification of RedCap UEs as summarized in Section 3, at least with respect to whether identification of RedCap UEs based on PRACH transmissions would be necessary.

It has also been observed in several contributions that suitability of some of the indication mechanisms also depends on whether SIB1 (and possibly other SI messages) for RedCap UEs are always separately scheduled from the SIB1 and other SI messages for regular NR UEs – either (i) due to constraints at PHY layer (e.g., considering impact on coverage for RedCap UEs, or to enable more flexible offloading of common control for RedCap UEs from the initial DL BWP determined by the SSB and CORESET 0 for regular NR UEs, etc.), or (ii) due to the need to provide significantly different configuration information via SI messages to RedCap UEs. While RAN1 is expected to discuss the first motivation, RAN2 would be the more appropriate group to determine the need to separate SI messages from the perspective of information content.

Based on the above summary, the following are proposed for further discussions.

***Note: In this and the next sections, the details of access control and device identification, as they may relate to definition of RedCap device type(s), are intentionally abstracted out (via simple reference to “RedCap UEs”) to decouple from the parallel discussions in AI 8.6.4 on device types. However, companies are welcome to provide feedback including such considerations as and when appropriate.***

## FL Proposal 1

* *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.*
    - ***~~Alt~~****~~.~~* ***~~E~~****~~: Via RACH procedure.~~*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | We wonder how Alt E can work for barring cell access from RedCap UEs. For example, Backoff Indicator in RACH is currently used for temporarily delaying RACH transmission, not for barring cell access.  **<Moderator>** Agree with the observation. To clarify, this list was compiled just based on inputs in tdocs without any pruning. Alt. E was proposed in [18], although not specifically mentioned for cell barring. However, it was included in the list above just to be all-inclusive. We could try to remove the option and see if anyone might have a different view. |
| ZTE | Y | Cell barring as early as possible is beneficial for UE power saving. The possibility of cell barring before SIB1 decoding should be studied in RAN1. |
| vivo | N | We cannot agree with proposal 1 at this stage.  This is a RAN2 lead objective. It is proper to be discussed in RAN2 first and RAN2 shall make the down-selection. Afterwards, RAN1 can discuss the detailed design for L1 signaling method if triggered by RAN2.  **<Moderator>** The intention is not to perform down-selection in RAN1 but only that RAN1 will also study these options from our perspective (PHY and system). However, there can be various details/considerations that fall within RAN1 expertise towards determining the potential options for cell barring, which could benefit the overall process if RAN1 also starts looking into these. |
| Nokia | Y | At present, our preference is for Alt C.  We believe this offers the best compromise in terms of network, UE and specifications impacts.  Options D and E, leave the “low level” barring of REDCAP UE to occur too late in the cell acquisition process, thereby:   * forcing the UE to consume more power that the other alternatives * forcing the SIB1 to be transmitted with potentially extra repetitions/frequency to accommodate REDCAP devices * forcing the UE to waste power with RACH transmissions   Alt A would be of interest, if we saw standalone REDCAP operation as a serious possibility, but at present we do not see that.  Alt B would be of interest, had there were more spare MIB bits available, but given the lack of spare bits (1 in most configurations), we do not feel this is a sensible option.  Note, we understand Vivo’s concern, but we think RAN1 can at least identify possible options/preferences for RAN2 to consider. |
| Samsung |  | We agree to discuss in RAN1 solutions that have RAN1 impact, however guidance from RAN2 is needed since RAN2 is discussing this topic. RAN2 input will affect which methods from the above list would be further discussed in RAN1. |
| Huawei, HiSilicon | Generally Ok but expects clarification/modifications | 1. Firstly, it is necessary to clarify and align the meaning of “cell barring”. Does it reflect the gNB’s capability to support RedCap UEs, or reflect the intention of load balance (assuming gNB already has the capability to support RedCap UEs)? 2. The term “separate” SSB is not very unclear. Could you clarify? 3. It is not clear how to acquire separate CORESET 0 if the same SSB used for Redcap UEs and legacy UEs. Ok to study but would prefer to have proponent’s clarification.   The gNB’s capability indication and load balance may be different depending on frequency ranges. Can we reflect this? |
| CMCC | Y | We agree the network should be able to control access of reduced capability NR devices to avoid performance degradation and realize traffic offloading.  We think Alt A, Alt B and Alt C can be further studied. |
| OPPO | Y | We think this can indicate a level special enhancement for RedCap UE which may have different need in UL/DL of initial access. Alt A, B and D would be choices and others can be discussed together. |
| Spreadtrum | Y | We think the network should indicate whether allowing RedCap UEs to access or not as early as possible. |

## FL Proposal 2

* *Study further on the need for supporting use of a DL BWP, that may be different from initial DL BWP defined by the SSB and CORESET 0, for SIB and/or other common control (RAR, paging) transmissions to RedCap UEs including those in Idle/Inactive modes, with focus on physical layer considerations, and taking into account at least:* 
  + *Impact to RedCap UEs (including at least complexity, power consumption, and performance)*
  + *Coexistence with regular/legacy UEs*
  + *System overhead*
* *Send an LS to RAN2 requesting for guidance on potential need for separating SIB1 and other SI messages for RedCap UEs from regular NR SIB1 and other SI messages from higher layer perspective.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | RAN2 would need to understand how much SIB1 information should be extended to support REDCAP UEs for their study on separate SIB1. It seems beneficial to inform RAN2 about new REDCAP specific configurations expected by RAN1, e.g. common channel configuration specific to REDCAP. |
| ZTE | N | The need for supporting use of a DL BWP different from initial DL BWP defined by SSB and CORESET 0 should be discussed in coexistence and specification impact part of 8.6.1 complexity reduction.  Whether to separate SIB1 and other SI for RedCap UE is RAN2 scope. No need to send an LS to RAN2 |
| vivo | Y if clarification is made | Our understanding of proposal 2 is about IDLE/INACTIVE state, correct?  **<Moderator>** Yes, that is correct. Now clarified in the Proposal 2 above. |
| Nokia | Y | We support further study of the initial BWP and SIB1 for REDCAP devices. One that also considers Idle/Inactive UEs.  We strongly support a LS to RAN2 for their guidance on a separate SIB1 specifically for REDCAP devices. Like LTE MTC, we see a number benefits of a separate “R-SIB1” for REDCAP devices, e.g. less impact to the non-REDCAP SIB1 (which could be transmitted unchanged) and simpler RAN2 specifications due to fewer changes being required to the format, structure and meaning of IEs (e.g. the UAC IEs). |
| China Telecom | Y | Whether to separate SIB1 and other SI for RedCap UE is RAN2 scope. |
| Samsung |  | We agree to discuss in RAN1 and coordinate with RAN2. We also agree in sending an LS to RAN2 as RAN2 will decide whether SIB1 and other SI messages for RedCap UEs will be separated by messages of regular NR UEs. |
| Huawei, HiSilicon | Y | Although we would be generally Ok to have study, it may need to verify if the current BWP can be also used or not for RedCap especially considering the number of RedCap UEs may not be large at early stage of commercialization. The design also needs to be future proof such that when later R17 RedCap UEs increase the system won’t be broken. We suggest the following modifications:   * *Study further on the need for supporting use of a DL BWP, that may be different from initial DL BWP defined by the SSB and CORESET 0, for SIB and/or other common control (RAR, paging) transmissions to RedCap UEs, with focus on physical layer considerations, and taking into account at least:*    + *Impact to RedCap UEs (including at least complexity, power consumption, and performance)*   + *Coexistence with regular/legacy UEs, on the same and/or different initial DL BWP*   + *Network scheduling flexibility*   + *System overhead* |
| CMCC | Y | We think the issue related to L1 signaling design if the separating SIB1 and other SI messages for RedCap UEs are supported should be discussed in RAN1. |
| OPPO | Y | We can determine introducing a DL BWP different from initial BWP, for the common control information transmission for RedCap UEs, if it is necessary considering impact to RedCap UEs, coexistence with regular/legacy UEs and system overhead. |
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## FL Proposal 3

* *Defer to RAN2 on temporary access barring schemes for congestion control.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | REL-15 UAC is a NAS/RRC function. RAN1 specification is seldom impacted by UAC. We think that UAC should be mainly discussed in RAN2, unless RAN2 asks RAN1 about RAN1 impact on it, if any. |
| ZTE | Y |  |
| vivo | Y | Same comment as to proposal 1, we think it should be discussed in RAN2 first. |
| Nokia | Y | In our view, the barring we are supporting in RAN1, is a simple/hard barring of all types/subtypes of REDCAP UEs (without impacting non-REDCAP UEs). The “soft” barring supported by RAN2 UAC, can and should be reused as much as possible. |
| China Telecom | Y | Same comment as to proposal 1. |
| Samsung | Y | No need to discuss in RAN1. |
| Huawei, HiSilicon | N | It may be difficult to proceed in ran1 based on whether “temporary access barring” in P3 or “soft access barring” in P4, as this is more about RAN2 mechanisms. In our view, we can combine the discussion of P3 and P4, and focus on a simple congestion control mechanism for RedCap UEs from RAN1 point of view is sufficient. |
| CMCC | Y |  |
| OPPO | Y |  |
| Spreadtrum | Y |  |

## FL Proposal 4

* *Study whether and how to realize soft access barring via PRACH resource and/or transmission configurations specific to RedCap UEs.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | If a solution impacts on RAN1, RAN1 can study. |
| ZTE | N | RAN2 scope |
| vivo | N | The same comment as for proposal 1. |
| Nokia | N | Unclear what is intended by this proposal;  (a) Is this another way of promoting Alt. E from the proposal 1?  (b) Proposal 5 addresses PRACH changes more clearly to us.  **<Moderator>** No. Proposal 1 was about cell barring, and in that context, now updated based on comment from LG. This is for the third type of access control to realize temporary access barring by adapting RA procedure configuration. Indeed, there is correlation between elements in Proposals 4 and 5.  Perhaps the Proposal 4 could have been framed better as a question, but hopefully, we get the same outcome based on feedback from companies. |
| China Telecom | N | This is a RAN2 lead objective. And RAN2 has already started the discussion,we prefer to wait or after receiving LS from RAN2. |
| Samsung | Y | We agree to study this in RAN1. |
| Huawei, HiSilicon | N | 1. Combine the proposal with P3. 2. Suggest to modify the proposal as:   *Study aspects related to access barring or congest control, including e.g. via signalling, PRACH resource, configurations/characteristics specific to RedCap UEs such as traffic type, UE capabilities.* |
| CMCC | N | This can be studied in RAN2. |
| OPPO | Y | RAN1 can study the PRACH resource and/or transmission configurations specific to RedCap UEs. If it is introduced, how to realize soft access barring can be considered afterwards. |

# 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.

Based on views in company contributions, the following stages at which RedCap UEs may be identified by the NW has been proposed:

* 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: During Msg5 transmission.

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 include:

* 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.).
* Limitations to max UL BW for RedCap UEs (e.g., for 50 MHz in FR2).
* 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 reduced for RedCap UEs, etc.

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).

## FL Proposal 5

* *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****: During Msg5 transmission.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | Early indication should be prioritized in this study. |
| ZTE | Y |  |
| vivo | N | First of all, there is current mechanism available that UE report its capability after successful RACH and security activation, which should also be part of the consideration for network to identify the UE type.  Secondly, this is an RAN2 lead objective, so the necessity of early indication beyond above mentioned existing mechanism should be justified in RAN2 first. And RAN1 discussion should be triggered by RAN2 afterwards. |
| Nokia | Maybe | In our view the need for Early indication is linked to the following questions:   * The number of REDCAP types we ultimately define and their respective physical coverage capabilities. * How we split/share RACH resources between these REDCAP/non-REDCAP types.   Since there are potential answers to these questions, that may mean early indication is not required (e.g. separate R-SIB1 indicating separated REDCAP specific RACH resources), we would first like these questions addressed. |
| China Telecom | N | RAN2 has already started the discussion,we prefer to study later based on RAN2 progress. |
| Samsung |  | OK to study in RAN1 but it needs coordination with RAN2.  It is noted that early identification is preferred, hence it can be avoided to study opt.3. |
| Huawei, HiSilicon | Y | Generally ok with the FL proposal. Want to also study the possibility of using msgA, thus suggest to change Opt. 1 as ‘Msg1/MsgA’. |
| CMCC | Y | Early indication can help network to realize access control as early as possible to avoid unnecessary resource waste. |
| OPPO | Y | These options can be studied further. |
| Spreadtrum | Y | It may be necessary for the early indication of some RedCap UE capabilities, e.g. bandwidth and Rx number. Early indication should be studied. |

# RRM relaxations and E-DRx for power savings

In contributions [3] and [11], 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). In [3], it has been highlighted that serving cell RRM measurements are likely to contribute significantly to the UE power consumption from RRM measurements in Idle/Inactive modes for stationary UEs, while [11] proposes RRM relaxations for both serving and neighbor cell measurements. Simulation results are presented in [3] to illustrate tolerable timing drift from less frequent SSB monitoring for stationary RedCap UEs. However, impact on CFO, and possibly on sampling time and frequency drift, may also need to be considered.

However, considering RAN2 is the leading WG for the objective on RRM relaxations for power consumption reduction, it may be more appropriate to wait for RAN2 to make progress on this issue.

## FL Proposal 6

* *Defer to RAN2 for further progress on studies regarding RRM relaxations for RedCap UEs to facilitate reduced UE power consumption.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | RRM relaxation can be first studied in RAN2. If RAN2 asks RAN1 to study RAN1 specific impact, RAN1 could study later. |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia | Y | Agree with proposal, defer to RAN2 for now. |
| China Telecom | Y |  |
| Samsung | Y |  |
| Huawei, HiSilicon | Y |  |
| CMCC | Y |  |
| OPPO | Y |  |
| Spreadtrum | Y |  |

Similarly, [11] proposes the introduction of extended DRx for RedCap UEs. However, as this SI objective is being led by RAN2, it is recommended to wait for RAN2 for conducting further studies on this.

## FL Proposal 7

* *Defer to RAN2 for further progress on studies regarding introduction of E-DRx for RedCap UEs to facilitate reduced UE power consumption.*

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| **Company** | **Agree (Y/N)** | **Comments** |
| LG | Y | RAN1 specific impact on e-DRX can be studied later based on RAN2 progress. |
| ZTE | Y |  |
| vivo | Y |  |
| Nokia | Y |  |
| China Telecom | Y |  |
| Samsung | Y |  |
| Huawei, HiSilicon | Y |  |
| CMCC | Y |  |
| OPPO | Y |  |
| Spreadtrum | Y |  |

# Other issues

Contributions [6] and [7], present views on considerations on max channel BW for RedCap UEs and are covered in discussion on AI 8.6.1.

Contribution [9] presents views on defining RedCap device types, and is covered in discussion on AI 8.6.4.

# References

1. RP-201386, Revised SID on Study on support of reduced capability NR devices.
2. R1-2005238, Identification and access restriction for RedCap, Ericsson
3. R1-2005387, RRM relaxation for Reduced Capability NR devices, vivo, Guangdong Genius
4. R1-2005478, Discussion on access control for Reduced Capability NR devices, ZTE
5. R1-2005718, Identification and access restriction for reduced capability NR devices, CATT
6. R1-2005934, Aspects related to bandwidth reduction, Lenovo, Motorola Mobility
7. R1-2005960, CBW for RedCap, NEC
8. R1-2005972, Discussion on the access control and configuration for reduced capability device, Beijing Xiaomi Software Tech
9. R1-2006040, Other considerations for reduced UE capability, OPPO
10. R1-2006156, Access barring and UE capability, Samsung
11. R1-2006270, Consideration on power saving for reduced capability NR devices, Spreadtrum Communications
12. R1-2006310, Support and control of initial cell access for reduced capability NR devices, LG Electronics
13. R1-2006411, Other aspects for reduced capability devices, Huawei, HiSilicon
14. R1-2006687, Access restriction for reduced capability NR devices, InterDigital, Inc.

1. [R1-2005386](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005386.zip), Framework and Principles for Reduced Capability, vivo, Guangdong Genius *(from AI 8.6.4)*

1. [R1-2005528](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005528.zip), Framework and Principles for Reduced Capability, Nokia, Nokia Shanghai Bell *(from AI 8.6.4)*

1. [R1-2005640](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005640.zip), On the framework for RedCap UEs, MediaTek Inc. *(from AI 8.6.4)*

1. [R1-2005832](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005832.zip), On Framework and Principles for RedCap, Lenovo, Motorola Mobility *(from AI 8.6.4)*

1. [R1-2005883](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005883.zip), Introducing NR RedCap UEs: Overall framework, Intel Corporation *(from AI 8.6.4)*

1. [R1-2005971](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005971.zip), Discussion on framework and principles for reduced capability device, Beijing Xiaomi Software Tech *(from AI 8.6.4)*

1. [R1-2006287](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006287.zip), Discussion on Framework and Principles for Reduced Capability, Spreadtrum Communications *(from AI 8.6.4)*

1. [R1-2006814](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006814.zip), Standardization Framework and Design Principles for RedCap Devices, Qualcomm Incorporated *(from AI 8.6.4)*

# Appendix A

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

[R1-2005238](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005238.zip) Identification and access restriction for RedCap Ericsson

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| *Observation 1: UE capabilities are known to gNB before data transmission or service initiation.*  *Observation 2: If required, options for early indication of RedCap UE include indication in Msg1 (RRC\_IDLE or RRC\_INACTIVE) or in Msg3 (RRC\_IDLE).*  *Observation 3: Preamble partitioning or separate PRACH for the purpose of early RedCap capability indication is not necessary and should be avoided.*  *Observation 4: The gNB can indicate in broadcast signalling (explicitly or implicitly) whether RedCap UEs are barred in the cell or not.*  *Observation 5: Unified Access Control can be reused for access barring and Access Categories and/or Access Identities could be used for identifying RedCap UEs or for categorizing RedCap access type.*  *Observation 6: Access restriction can be achieved by using RedCap specific PRACH configuration, or RedCap specific configuration of some RACH parameters.* |

[R1-2005387](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005387.zip) 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.* |

[R1-2005478](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005478.zip) Discussion on access control for Reduced Capability NR devices ZTE

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| *Observation1: The possibility to use the spare bit in MIB payload for access control signaling for reduced capability NR devices is very low due to only one spare bit in MIB payload.*  *Observation2: The access control signaling for reduced capability NR devices could be carried in SIB1 or the DCI scheduling SIB1.*  *Observation 3: If the reduced capability UE cannot be identified during initial access, scheduling limitation or configuration limitation may be needed for normal NR UEs.*  *Proposal 1: Access control for reduced capability NR devices should be considered.*  *Proposal 2: An access control signaling for reduced capability NR devices is carried in DCI scheduling SIB1.*  *Proposal 3: Identification of the reduced capability UE type by Msg1 or Msg3 shall be considered depending on the maximum UE bandwidth agreed for the reduced capability NR devices.* |

[R1-2005718](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005718.zip) Identification and access restriction for reduced capability NR devices CATT

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| *Proposal 1: Indication should be introduced in SIB1 to indicate whether the UE with reduced capabilities is allowed to access this cell.*  *Proposal 2: UAC mechanism should be reused to control the access of device with reduced capabilities by definition of separate access identity or separate access category with set separate UAC barring parameters.*  *Proposal 3: Further discuss whether it is necessary for the network to identify the device type earlier than the UE capabilities report.* |

[R1-2005972](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005972.zip) Discussion on the access control and configuration for reduced capability device Beijing Xiaomi Software Tech

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| *Proposal 1: Network access control to RedCap UE should be explicitly indicated as early as possible.*  *Proposal 2: Mechanism to let network acknowledge the RedCap devices in early access stage should be supported.* |

[R1-2006156](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006156.zip) Access barring and UE capability Samsung

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| *Proposal #1: Support early access for identification for RedCap UEs during random access.*  *Proposal #2: Study access barring mechanisms for cell access control for RedCap UEs to ensure efficient network operation.* |

[R1-2006310](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006310.zip) Support and control of initial cell access for reduced capability NR devices LG Electronics

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| *Observation 1A: It is beneficial for REDCAP UEs to identify whether a cell supports REDCAP in cell access as early as possible.*  *Observation 1B: The IE cellBarred in MIB currently used by normal UEs could not be used to control REDCAP UEs only.*  *Proposal 1: Study a mechanism for REDCAP UEs to identify whether a cell supports REDCAP before decoding PDSCH transmission carrying SIB1.*  *Observation 2A: It seems beneficial for gNB to provide separate RACH resources for REDCAP UEs and normal UEs, e.g. due to supported UE bandwidth or load control, which can be also used for identification of REDCAP UEs.*  *Observation 2B: If separate RACH resources are configured for REDCAP UEs, it seems not so necessary to configure separate RACH resources only within the same UL BWP for REDCAP UEs and normal UEs.*  *Observation 2C: REDCAP UEs may not support the bandwidth of the initial UL BWP configured for normal UEs in SIB1 depending on REL-15 cell configuration.*  *Proposal 2: Study possibility of using a separate UL BWP for initial access of REDCAP UEs (as well as common UL BWP shared with normal UEs).*  *Observation 3: Support of REDCAP UEs in a cell may impact SIB1 size e.g. for cell access control/restriction and common configuration used by REDCAP UEs.*  *Proposal 3: Study a mechanism for scheduling new SIB1 (e.g. SIB1bis) used by REDCAP UEs.*  *Observation 4A: If new SIB1 is used by REDCAP UEs, it seems not so necessary to transmit new SIB1 and legacy SIB1 only within the same DL BWP for REDCAP UEs and normal UEs.*  *Observation 4B: REDCAP UEs may not support the bandwidth of the initial DL BWP configured for normal UEs in SIB1 depending on REL-15 cell configuration.*  *Proposal 4: Study possibility of using a separate DL BWP for SIB transmissions towards REDCAP UEs.* |

[R1-2006411](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006411.zip) Other aspects for reduced capability devices Huawei, HiSilicon

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| *Proposal 1: Network should indicate its capability of whether it supports NR RedCap UEs accessing or not to aid RedCap UE’s cell selection.*  *Proposal 2: Network should indicate whether it allows NR RedCap UEs accessing or not, and legacy access control mechanism can be reused.*  *Proposal 3: Support the ability for the network to allow or bar access for all RedCap UEs, or RedCap UEs with a specific set of capabilities.*  *Proposal 4: NR RedCap UEs are identified via the RACH procedure.* |

[R1-2006687](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006687.zip) Access restriction for reduced capability NR devices InterDigital, Inc.

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| *Proposal 1: Discuss whether to introduce new device types for RedCap UEs*  *Proposal 2: Discuss whether to introduce a new initial access mechanism for RedCap UEs.*  *Proposal 3: Study early identification of RedCap UEs.*  *Proposal 4: Study access restriction and access barring for RedCap UEs.* |

[R1-2005386](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005386.zip) Framework and Principles for Reduced Capability vivo, Guangdong Genius

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| *Observation 1: the tradeoff between economics of scale and cost/power efficiency should be carefully considered when defining the RedCap UE categories or types.*  *Observation 2: It is beneficial to support offloading IDLE mode RedCap UE to a different initial BWP than the legacy initial BWP.*  *Observation 3:*   * *If separate CORESET#0 and shared SSBs are introduced for RedCap UEs, UE may need to perform frequent RF retuning to receive SSB for synchronization, RRM, etc which complicates the IDLE mode UE behavior.* * *If separate CORESET#0 and separate SSBs are introduced for RedCap UEs, UE frequent RF retuning can be avoided but it requires additional overhead.*   *Observation 4:*  *Separate RACH resources is beneficial for gNB to identify the RedCap UEs at early stage and easy to implement RedCap-specific design for subsequent transmissions/receptions.*  *Proposal 1: introduce two RedCap UE categories/ types, one is to cover the low-end use cases, the other is to cover the high-end use cases:*   * *Type 1 RedCap UEs for industrial sensors, economic video, low-end wearable use cases* * *Type 2 RedCap UEs for high-end wearable and high-end video Surveillance use cases*   *Proposal 2: For cell search, study following options for RedCap UEs and legacy UEs:*   * *Option 1: Shared SSB, separate CORESET#0* * *Option 2: separate SSB, separate CORESET#0*   *Proposal 3: For random access, study following options for RedCap UEs and legacy UEs:*   * *Option 1: shared PRACH resource* * *Option 2: separate PRACH resource*   *Proposal 4: Different Access Identities can be used in UAC for High-end, Low-end wearable and Low-end industry RedCap devices to enable applying different access control strategies on RedCap devices belonging to different groups.*  *Proposal 5: different Access Categories can be used in UAC to differentiate accesses from high-end RedCap devices, low-end wearable RedCap devices and low-end industry RedCap devices in case the access are triggered by the same type of service.* |

[R1-2005528](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005528.zip) Framework and Principles for Reduced Capability 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: Using reserved values for UE access identity to enhance the existing UAC mechanism to enable barring of REDCAP devices is undesirable because:*   * *Access identities are intended to be hardware agnostic* * *Using new access identities specifically for REDCAP devices, would require a new set of access rules to be created for different combinations of access identity and category* * *Legacy SIB1 must now be transmitted in such a way (i.e. with sufficient repetitions/frequency) to ensure the coverage needs of REDCAP devices are met.*   *Observation 5: Using reserved values for UE access category to enhance the existing UAC mechanism to enable barring of REDCAP devices is undesirable because:*   * *Legacy SIB1 must now be transmitted in such a way (i.e. with sufficient repetitions/frequency) to ensure the coverage needs of REDCAP devices are met.* * *RRC Connection between the REDCAP device and the network is required for the network to signal the “new” operator defined UE access categories.*   *Observation 6: User Subscription data could be used to bar different devices, however this would require the device to establish a RRC connection first.*  *Observation 7: The network can retrieve detailed REDCAP device physical layer capabilities from the UE radio access capability information procedure, however this would require the device to establish a RRC connection first.*  *Observation 8: Requiring REDCAP devices to enter RRC Connected mode to determine if the cell supports REDCAP and/or if REDCAP devices are barred, is an inefficient use of resources for both the Network and the UE.*  *Observation 9: A method to bar idle mode REDCAP devices. should also indicate if the cell is REDCAP capable to prevent REDCAP devices from unnecessarily wasting resources attempting to access a non-REDCAP capable cells.*  *Proposal 1: Spare Bits in the DCI used to schedule SIB1, are used to support REDCAP devices in determining:*   * *If the cell is REDCAP capable* * *If REDCAP service is barred*   *Proposal 2: RAN1 and RAN2 determine if a separate SIB1 for REDCAP devices, R-SIB1, is specified.*  *Proposal 3: If a separate R-SIB1 is specified for REDCAP devices, spare bits in the DCI that are used to schedule SIB1, are used to support REDCAP devices in determining:*  *• The scheduling of R-SIB1* |

[R1-2005640](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005640.zip) On the framework for RedCap UEs MediaTek Inc.

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| *Proposal 1: A RedCap UE only camps on a cell that indicates support of RedCap operation.*  *Proposal 2: Support of RedCap operation in a cell is broadcasted by the network.*  *Proposal 3: A RedCap UE that is registered to a network is identified by the network at msg5.* |

[R1-2005832](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005832.zip) On Framework and Principles for RedCap Lenovo, Motorola Mobility

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| *Observation 1: For FR1, 20MHz UE bandwidth could well meet the data rate requirements of RedCap use cases.*  *Observation 2: For FR2, 50MHz UE bandwidth could well meet the data rate requirements of RedCap use cases.*  *Observation 3: The gNB could control the access of RedCap UEs in different stages during initial access, depending on different design.*  *Proposal 1: Define one or two device types with 20MHz maximum UE bandwidth for FR1.*  *Proposal 2: Define one device type with 50MHz maximum UE bandwidth for FR2.*  *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 or Msg3.* |

[R1-2005883](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005883.zip) Introducing NR RedCap UEs: Overall framework Intel Corporation

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| *Observation 1: Ensuring that a particular device type is only used for the intended use case is possible using existing capability signalling framework or device types. The actual check can be left to the network.*  *Proposal 1: The SI objective of “checking device is used only as intended” can be met using existing capabilities or a device type.*  *Proposal 2: “Device types” concept is introduced for RedCap devices.*  *Proposal 3: Device type is used as an additional mechanism on top of explicitly signalling all the UE capabilities as in legacy NR. The number of device types should be minimised and introduced only where essential to control UE accesses and industry classification.*   * *This could be realized based on the minimum requirements on the channel BW, which is a common and most significant property that is expected to be different from regular NR UEs.*   *Proposal 4: If it is found necessary for network to be aware of certain UE capability during initial access, the information can be carried by PRACH resource or PRACH preamble partitioning or in msg 3.*  *Observation 2: Conceptually, use of device type makes it easier to enable access restriction and also reduces the signalling overhead.*  *Proposal 5: Device type concept is used for controlling access to the cell. Acceptability of a cell is based on broadcast access permissions for the given device types.* |

[R1-2005971](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005971.zip) Discussion on framework and principles for reduced capability device Beijing Xiaomi Software Tech

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| *Proposal 1: More than one Redcap device types providing different peak data rate should be supported to adapt different use cases*  *Proposal 2: 1Rx/1Tx and 20MHz bandwidth should be assumed as the basic RedCap device type.*  *Proposal 3: Further study the following two options for the high-end device type*   * *Option 1: 40MHz and 1 Rx* * *Option 2: 20MHz and 2Rx*   *Proposal 4: Early identification of RedCap capability by RACH procedure can be considered.*  *Proposal 5: RedCap specific coverage recovery enhancement should be discussed in the RedCap SID.* |

[R1-2006287](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006287.zip) Discussion on Framework and Principles for Reduced Capability Spreadtrum Communications

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| *Proposal 1: Network should indicate whether allowing RedCap UEs accessing or not.*  *Proposal 2: Network should indicate whether allowing RedCap UEs accessing or not explicitly or implicitly as early as possible.*  *Proposal 3: Study the early indication of RedCap UE capability.* |

[R1-2006814](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006814.zip) Standardization Framework and Design Principles for RedCap Devices Qualcomm Incorporated

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| *Proposal 1: Study how and how many RedCap device types are defined.*   * *In case a single RedCap device type is defined, the device type should cover a wide range of use cases and requirements.* * *In case two RedCap device types are defined, consider one type for low-end RedCap devices and the other for high-end RedCap devices.*   *Proposal 2: Study the co-existence of RedCap devices with NR Rel-15/16 UE and minimize the L1 impacts by:*   * *re-using the waveform, numerologies, channel coding, physical signals and control/data channel structure of NR Rel-15* * *re-using the UE capability transfer mechanism of NR Rel-15 after RRC connection* * *re-using the PSS/SSS sequences and PBCH/SIB1design of NR Rel-15*   *Proposal 3: Study enhancements of existing access control procedures and frameworks to support restricted use and restricted access for NR Rel-17 RedCap UEs.*  *Proposal 4: Study a mechanism for UE to indicate it has only reduced capability during connection establishment procedure.*  *Proposal 5: Study coverage recovery and coverage enhancement separately in different SI, until commonalities and differences in terms of potential solutions and standardization impacts are well understood. After that, RAN1 can further discuss whether/how to merge some of the topics that have been studied by both SI.*  *Proposal 6: For FR2, study a separate cell search and initial access design for RedCap devices to balance early discovery of RedCap systems (UE power and acquisition time), resource overhead, and network flexibility.*   * *Separation may be from SSB, CORESET0, RMSI, or RACH* * *Study techniques to reduce the resource duplications due to such separation*   *Proposal 7: For FR2, study more efficient ways to:*   * *reduce beam overloading and interference for stationary or slow moving UEs;* * *reduce beam direction blockage to accommodate other UEs in times when beams are preconfigured for RedCap UEs.*   *Proposal 8: For FR2, study ways to reduce the UL and DL resources utilizations for RedCap devices by:*   * *utilizing a leaner RedCap design* * *re-using as much as possible resources used by the non-RedCap UE*   *Proposal 9: For FR2, study additional ways to mitigate PRACH collisions and resource overloading to improve UE power efficiency and latency.* |

# Appendix B

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

[R1-2005387](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2005387.zip) 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.* |

[R1-2006270](file:///C:\Users\dchatt2\OneDrive%20-%20Intel%20Corporation\Documents\work\3gpp\RAN1\Contribution%20reviews\RAN1_102-E_contribution_review\allTdocs_R1_102E\R1-2006270.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.*  *Proposal 3: Extended DRX in RRC Inactive and/or Idle mode can be introduced for RedCap UEs in some scenarios.* |