3GPP TSG-RAN WG1 Meeting #105-e R1-21xxxxx

e-Meeting, 10th – 27th May 2021

**Agenda Item: 8.6.2**

**Title: FL summary #1 on RAN1 aspects for RAN2-led features for RedCap**

**Source: Moderator (NTT DOCOMO, INC.)**

**Document for: Discussion, Decision**

# Introduction

This document summarizes contributions [1] – [25] submitted to agenda item 8.6.2 and relevant parts of contributions [26] – [30] submitted to agenda item 8.6.3 and captures the following email discussion for the RedCap WI.

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| [105-e-NR-R17-RedCap-05] Email discussion regarding RAN1 aspects for RAN2-led features – Shinya (DoCoMo)   * 1st check point: 5/21 * 2nd check point: 5/25 * Final check: 5/27 |

The issues in this document are tagged and colour coded with High priority or Medium priority.

In this round of the discussion, companies are requested to provide comments on the proposals and questions tagged FL1.

Follow the naming convention in this example:

* *RedCapBwFLS1-v000.docx*
* *RedCapBwFLS1-v001-CompanyA.docx*
* *RedCapBwFLS1-v002-CompanyA-CompanyB.docx*
* *RedCapBwFLS1-v003-CompanyB-CompanyC.docx*

If needed, you may “lock” a spreadsheet file for 30 minutes by creating a checkout file, as in this example:

* Assume CompanyC wants to update *RedCapR2ledFLS1-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *RedCapR2ledFLS1-v003-CompanyB-CompanyC.checkout*
* CompanyC then has 30 minutes to upload *RedCapR2ledFLS1-v003-CompanyB-CompanyC.docx*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

In file names, please use the hyphen character (not the underline character) and include ‘v’ in front of the version number, as in the examples above and in line with the general recommendation (see slide 10 in [R1-2104152](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104152.zip)), otherwise the sorting of the files will be messed up (which can only be fixed by the RAN1 secretary).

To avoid excessive email load on the RAN1 email reflector, please note that there is NO need to send an info email to the reflector just to inform that you have uploaded a new version of this document.

# Definition of RedCap UE type

The WID [31] has the following objective on the definition of RedCap UE type:

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| * Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths. [RAN2, RAN1]   + The existing UE capability framework is used; changes to capability signalling are specified only if necessary. |

As stated in the above objective and also mentioned in a number of contributions [1, 3, 14, 15, 22], only one RedCap UE type will be specified in this WI. However, several contributions [12, 13, 16] propose to define more than one RedCap UE types. One contribution [12] proposes to define two UE types for FR1 and at least one UE type for FR2 with use case/RedCap UE type orientated RedCap UEs features. One contribution [12] proposes to define two stage definition/identification of UE type, i.e., initial UE type identified by a first identification (e.g. PRACH/Msg1) and later signalling (e.g. Msg5 or capability signalling) refine/change the UE type and its parameters.

**FL1 High Priority Question 2-1:**

* **According to the WID, will only one RedCap UE type be defined? If not, please provide your interpretation of the WID and the reason why we need more than one RedCap UE types.**

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| **Company** | **Y/N** | **Comments** |
| ZTE, Sanechips | Y | One RedCap UE type for each FR |
| Huawei, HiSi |  | Crystal clear that only one RedCap UE type is supported according to the WID |
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Many contributions [1, 3, 4, 6, 9, 14, 15, 17, 22] discuss how to define the RedCap UE type. Several contributions propose to define the RedCap UE type based on one of the following options captured in TR38.875. Some contributions [6, 9] support Option 2 while some others [1, 3, 6] support Option 4. In addition, one contribution [17] propose that the definition of RedCap UE type only includes minimum set of capabilities that the network needs to know during initial access. One contribution [4] propose relative criterion(s) compared between the UE capability and cell operating parameters; at least the comparison on maximum channel bandwidth for a UE can support and a cell can operate (e.g. as specified in Table 5.3.5-1 for FR1 in TS 38.101-1 and Table 5.3.5-1 for FR2 in TS 38.101-2) should be used as one criterion. One contribution [4] suggest that UE declaration of RedCap/non-RedCap is band-specific.

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| At least for RedCap UE identification, explicit definition of RedCap UE type(s) is needed. Pending conclusions on the reduced complexity features (as described in clauses 7 and 12) and RedCap UE identification (as described in clause 11), the definition of the RedCap UE types can be based on one of:  - Option 1: All the reduced capabilities recommended at the end of the RedCap study  - Option 2: Only include the reduced capabilities that the network needs to know during initial access, if any.  - Option 3: All the recommended reduced capabilities as well as recommended power saving features  - Option 4: The corresponding minimum set of the reduced capabilities that one RedCap UE type shall mandatorily support |

**Medium Priority Question 2-2:**

* **Can RedCap UE type be defined based on one of the following options? If not, please provide your view how it should be defined.**
  + **Option 1: All the reduced capabilities recommended at the end of the RedCap study**
  + **Option 2: Only include the reduced capabilities that the network needs to know during initial access, if any.**
  + **Option 3: All the recommended reduced capabilities as well as recommended power saving features**
  + **Option 4: The corresponding minimum set of the reduced capabilities that one RedCap UE type shall mandatorily support**

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| **Company** | **Y/N** | **Comments** |
| Huawei, HiSi |  | Option 2 or 4. |
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Several contributions [1, 3, 9, 14, 15, 17, 22] discuss the capabilities included in the definition of the RedCap UE type. Many of them [1, 3, 14, 15, 17, 22] suggest that Maximum UE bandwidth (i.e., 20MHz for FR1 and 100MHz for FR2) is included. One contribution [1] suggests that the capabilities of minimum number of Rx branches (1Rx only), maximum number of DL MIMO layers (1 for 1 Rx, 2 for 2Rx), maximum modulation order (64QAM), duplex operation (HD-FDD and TDD) are also included. One contribution [9] suggests that the capability of minimum number of Rx branches of 1Rx or 2Rx is included. In addition, One contribution [17] suggests that the capability of highest MCS is included.

**Medium Priority Question 2-3:**

* **Which reduced capability should be included in the definition of RedCap UE type?**

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| **Company** | **Comments** |
| Huawei, HiSi | UE max bandwidth is key differentiation factor between RedCap UEs and non-RedCap UEs, in both spec and implementation wise. |
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One contribution [11] propose that discussion of definition of RedCap UE type in RAN1 should wait until after progress is made in RAN2 and RAN1 has decision on early identification.

**FL1 High Priority Question 2-4:**

* **Should RAN1 wait the discussion of definition of RedCap UE type until some progress is made in RAN2 and RAN1 has decision on early identification? If yes, please provide your view when we can resume RAN1 discussion.**

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| **Company** | **Y/N** | **Comments** |
| ZTE, Sanechips | Y | Resume at least RAN1 has decision on which capabilities should be early identified |
| Huawei, HiSi | N | RAN1 is also tasked as per WID for discussion. Actually, RAN2 is expecting RAN1 input  Agreement in RAN2#111-e:  The number of device types should be minimised, to reduce market fragmentation, and introduced only where essential to control UE accesses and differentiate them from legacy R15/R16 and non-Redcap R17 UEs, (e.g. number of Tx/Rx antennas, maximum supportable BW, etc.). The exact composition of the set of L1 capabilities of the device type can be discussed by RAN1 |
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A few contributions [1, 6] discuss constraining of reduced capabilities. One contribution [1] proposes to achieve the functionality by disallowing some UE capabilities for RedCap and non-RedCap UEs, respectively, while the detailed signalling is up to RAN2. One contribution [6] proposes to deter to RAN2.

**FL1 High Priority Question 2-5:**

* **Should RAN1 discuss constraining of reduced capabilities? If yes, please provide your view what should be discussed in RAN1.**

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| **Company** | **Y/N** | **Comments** |
| ZTE, Sanechips | N | Can be handled in RAN2 only |
| Huawei, HiSi | Rather than “should”, Can may be more proper | RAN1 can discuss but we currently don’t see what needs to be constrained according to the WID, except for those explicitly given by WID, i.e. CA/DC related capabilities and a larger BW than the agreed Max UE bandwidth. Can review this when more features are clear or RAN1 to have a high level guidance. |
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# Early indication of RedCap UEs

The WID [31] has the following objective on early indication of RedCap UEs:

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| * Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks through an early indication in Msg1 and/or Msg3, and Msg A if supported, including the ability for the early indication to be configurable by the network. [RAN2, RAN1] |

***Note that potential early indication of the number of Rx branches, which is discussed in many contributions [3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 17, 21, 25], will be discussed in AI8.4.1.2.***

Many contributions [1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25] support the early indication of RedCap UEs in Msg1, and some of them [1, 3, 6, 7, 20, 23] also suggest that the indication is configurable (e.g., via SIB1 [3]). However, there are divergent views on the detailed solution to differentiate RedCap UEs from non-RedCap UEs, such as via separate initial UL BWP [9, 11, 14, 15, 22], separate PRACH resource [3, 7, 9, 14, 25] or PRACH preamble partitioning [1, 3, 7, 10, 11, 14, 15, 22], as it is related to the discussion whether initial UL BWP for RedCap UEs is the same as that for non-RedCap UEs or not in AI8.6.1.1.

A number of contributions [1, 3, 8, 9, 18, 21] support the early indication of RedCap UEs in Msg3, and one of them [1] also suggests that it is up to RAN2 whether the indication is configurable or not. Also, a number of contributions [1, 3, 8, 9, 18, 21] suggest that the indication is configurable between Msg1 and Msg3 (and also MsgA [18]).

**FL1 High Priority Proposal 3-1:**

* **For 4-step RACH, support the early indication of RedCap UEs at least in Msg1.**
  + **FFS whether/how to support early indication of RedCap UEs in Msg3 in addition to Msg1.**
  + **FFS detail, e.g.:**
    - **separate initial UL BWP**
    - **separate PRACH resource**
    - **PRACH preamble partitioning**

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| **Company** | **Y/N** | **Comments** |
| ZTE, Sanechips | Y |  |
| Huawei, HiSi |  | We think we can first agree on the configurability of early identification then to see whether to support one of Msg1 and Msg3, or both. |
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A few contributions [17, 18, 23] support the early indication of RedCap UEs in MsgA and one of them [23] also suggests that the indication is configurable. One contribution [1] suggest that RAN1 discusses whether coverage recovery for MsgB is necessary or not as it should be clarified to select whether the early indication is done in the preamble part or the PUSCH part of MsgA. Also, one contribution [1] suggest that the discussion for 4-step RACH is prioritized.

**Medium Priority Question 3-2:**

* **Do we support 2-step RACH for RedCap UEs? If yes, please provide your view which aspects we should study/specify dedicated to 2-step RACH (i.e., delta from 4-step RACH).**

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| **Company** | **Y/N** | **Comments** |
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A number of contributions [6, 14, 17, 21, 27] suggest that CovEnh UE is taken into account for the early indication. One contribution [23] proposes that UE is identified as RedCap during UE capability reporting If early indication is not configured.

**Medium Priority Question 3-3:**

* **Do we need to take CovEnh UE into account for the early indication of RedCap UEs? If yes, please provide your view how to proceed the specification work (e.g., RedCap WI and CovEnh WI can discuss it separately, or only one of them should discuss it with taking the other’s aspect into account).**

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| **Company** | **Y/N** | **Comments** |
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# System information indication

The WID [31] has the following objective on system information indication:

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| * Specify a system information indication to indicate whether a RedCap UE can camp on the cell/frequency or not; it shall be possible for the indication to be specific to the number of Rx branches of the UE. [RAN2, RAN1] |

A few contributions [1, 14, 18] suggest that this topic is not considered in RAN1. One contribution [6] suggests that RAN1 can try to reach high level consensus on signaling design and inform the conclusions to RAN2 for discussion/decision if RAN1 discusses this topic ahead of RAN2. Also, another contribution [13] suggests that RAN1 can study and make down-selection for the options of system information indication with considering RAN2 further progress.

**FL1 High Priority Question 4-1:**

* **Should RAN1 discuss system information indication for access control? If yes, please provide your view what should be discussed in RAN1.**

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| **Company** | **Y/N** | **Comments** |
| ZTE, Sanechips | Y | Early indication of access control before SIB1 should be discussed in RAN1.  Consider to carry early indication of access control in DCI scheduling SIB1 by using the reserved bit(s). |
| Huawei, HiSi | Y | RAN1 is explicitly tasked as per WID.  Early access control is good for power consumption, and there is only 1 spare bit in MIB. Some companies propose to restrict the accessing in DCI scheduling SIB1, which is also related to RAN1 and can be informed to RAN2 when necessary. |
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A number of contributions [3, 7, 9, 10, 17, 19, 23, 29] discuss what kind of system information indication is necessary. Several contributions [3, 9, 19, 23] propose the indication whether NW supports RedCap UEs accessing or not. Some other contributions [3, 7, 9, 10, 17, 19] propose the access control specific to RedCap UEs with 1Rx or 2Rx. Another contribution [9] suggests that the NW broadcasts the priority level of RedCap devices that to be served. Another contribution [17] propose a scheme restricting RedCap UEs with poor channel conditions from accessing the network. Another contribution [29] suggests that gNB can deprioritize RedCap UEs e.g. with 1-Rx capability by configuring lower RACH opportunity.

A number of contributions [3, 7, 9, 10, 11, 13, 19, 20, 23, 30] discuss how to indicate the system information as follows:

* PBCH: [9], [20]
* DCI associated with SIB1: [3, 7, 9, 11, 13, 19, 20]
* SIB1: [9, 10, 13, 30]
  + Reuse existing SIB1 to incorporate the new system information for RedCap [30]
  + When the existing SIB1 is extended to incorporate the new IE for RedCap, consider the following options to improve the power efficiency during system information updating [30]
    - Option 1: Define separate systeminfoModification field in paging DCI.
    - Option 2: Paging messages of RedCap devices and non-RedCap devices are not multiplexed in the same paging resource
* RA procedure: [9]
* Explicit indication in SI: [23]

# Necessary updates of UE capabilities and RRC parameters

The WID [31] has the following objective on the necessary updates of UE capabilities and RRC parameters:

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| * Specify necessary updates of UE capabilities (38.306) and RRC parameters (38.331). [RAN2] |

A few contributions [22, 26, 27, 28] discuss whether/how current UE capabilities and RRC parameters should be updated.

One contribution [28] suggests that RAN1 discuss which features are supported to satisfy the basic requirements (latency, reliability, complexity and for longer battery life) for RedCap UE, and remaining features are not supported by default. However, there would be another interpretation that current definition of mandatory/optional support of UE capabilities in TS38.306 is reused for RedCap UEs by default unless any update is identified, e.g., maxNumberMIMO-LayersPDSCH as discussed below. One contribution [26] suggests that at least for the features that are mandatory without capability signalling for non-RedCap UEs, the RedCap UEs support mandatorily with the same value.

**Medium Priority Question 5-1:**

* **Which of the following alternatives should we assume to discuss the necessary updates of UE capabilities?**
  + **Alt-1: Identify the UE capabilities to satisfy the basic requirements for RedCap UE, where remaining UE capabilities are not supported by default**
  + **Alt-2: Current definition of mandatory/optional support of UE capabilities in TS38.306 is reused for RedCap UEs by default unless any update is identified**
  + **Alt-3: Any others (please provide the detail assumption if you prefer this)**

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| **Company** | **Comments** |
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Following capabilities are pointed out by some contributions that update is necessary:

* maxNumberMIMO-LayersPDSCH: Optional [26], add a new value [22]
* pdsch-256QAM-FR1: Optional [26]
* csi-RS-RLM: Optional [26]
* oneFL-DMRS-TwoAdditionalDMRS-UL: Not necessary [26]
* spatialBundlingHARQ-ACK: Not necessary [26]
* additionalActiveTCI-StatePDCCH/additionalActiveSpatialRelationPUCCH: Optional [26]
* Capabilities related to the carrier aggregation, dual connectivity: do not support [26]
* Capabilities related to power saving: FFS whether RedCap UEs mandatorily support [26][27]
* Capabilities related to the processing timeline: Use the same value as the one for non-RedCap UEs [26]

One contribution [27] mentions the cost of RedCap UE may be further reduced by reducing the maximum value of parameters.

# Other aspects

**SI framework (other than system information indication in Section 4)**

* Study a mechanism for scheduling new SIB1 (e.g. SIB1-R) used by REDCAP UEs [19]
  + 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
* gNB may provide different configurations for transmissions of other SI for REDCAP UEs and non-REDCAP UEs. (e.g. AL or separate DL BWP) [19]
  + REDCAP specific RACH resources can be configured for gNB to transmit on-demand SI message

# References

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| --- | --- | --- | --- |
| [1] | [R1-2104183](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104183.zip) | RAN1 aspects for RAN2-led features for RedCap | Ericsson |
| [2] | [R1-2104191](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104191.zip) | Discussion on the Identification of RedCap UEs | FUTUREWEI |
| [3] | [R1-2104287](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104287.zip) | RAN1 aspects of RedCap UE type and identification | Huawei, HiSilicon |
| [4] | [R1-2104369](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104369.zip) | Higher layer support for RedCap | vivo, Guangdong Genius |
| [5] | [R1-2104431](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104431.zip) | Discussion on early indication for RedCap UE | Spreadtrum Communications |
| [6] | [R1-2104530](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104530.zip) | Discussion on higher layer support of RedCap | CATT |
| [7] | [R1-2104546](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104546.zip) | Higher layer support of Reduced Capability NR Devices | Nokia, Nokia Shanghai Bell |
| [8] | [R1-2104562](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104562.zip) | Design consideration for Higher layer support of RedCap | Sierra Wireless, S.A. |
| [9] | [R1-2104620](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104620.zip) | Discussion on higher layer support of RedCap UE | CMCC |
| [10] | [R1-2104681](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104681.zip) | Cross Layer Design Considerations for RedCap Device | Qualcomm Incorporated |
| [11] | [R1-2104714](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104714.zip) | Higher layer support of Reduced Capability NR devices | ZTE, Sanechips |
| [12] | [R1-2104785](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104785.zip) | Mechanism in higher&PHY layer for Reduced Capability NR Devices | OPPO |
| [13] | [R1-2104853](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104853.zip) | Discussion on RAN1 aspects for RAN2-led features for RedCap | China Telecom |
| [14] | [R1-2104915](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104915.zip) | On RedCap UE types: Definition, access control, and identification | Intel Corporation |
| [15] | [R1-2105115](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105115.zip) | On Higher Layer Support of Redcap Devices | Apple |
| [16] | [R1-2105173](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105173.zip) | UE identification of redcap devices | Sony |
| [17] | [R1-2105220](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105220.zip) | UE identification and access control for RedCap | Lenovo, Motorola Mobility |
| [18] | [R1-2105320](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105320.zip) | RAN1 aspects for RAN2-led features for RedCap | Samsung |
| [19] | [R1-2105432](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105432.zip) | RAN1 aspects for RAN2-led features for RedCap | LG Electronics |
| [20] | [R1-2105571](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105571.zip) | Discussion on the early indication and access control | Xiaomi |
| [21] | [R1-2105638](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105638.zip) | RAN1 aspects for RAN2-led features for RedCap | Sharp |
| [22] | [R1-2105707](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105707.zip) | Discussion on RAN1 aspects for RAN2-led features for RedCap | NTT DOCOMO, INC. |
| [23] | [R1-2105749](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105749.zip) | Identification and restriction of RedCap UEs | InterDigital, Inc. |
| [24] | [R1-2105876](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105876.zip) | Discussion on higher layer support of Redcap UE | WILUS Inc. |
| [25] | [R1-2105885](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105885.zip) | On RedCap UE early identification | Nordic Semiconductor ASA |
| [26] | [R1-2104370](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104370.zip) | Discussion on reduced capability signaling | vivo, Guangdong Genius |
| [27] | [R1-2104531](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104531.zip) | Views on remaining issues of RedCap | CATT |
| [28] | [R1-2104715](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104715.zip) | NR UE features for RedCap | ZTE, Sanechips |
| [29] | [R1-2105433](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105433.zip) | Discussion on other aspects of RedCap | LG Electronics |
| [30] | [R1-2105572](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105572.zip) | Discussion on the transmission of system information for RedCap | Xiaomi |
| [31] | [RP-210918](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Docs/RP-210918.zip) | Revised WID on support of reduced capability NR devices | Nokia, Ericsson |