3GPP TSG RAN WG2 Meeting #114 [Draft] R2-2106521

**Electronic meeting, 19th-27th May 2021**

**Agenda item:** 8.12.2.1

**Source:** Intel Corporation

**Title:** Summary of [AT114-e][105][RedCap] Definition of RedCap UE and reduced capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This document is the summary of following offline discussion:

**\* [AT114-e][105][RedCap] Definition of RedCap UE and reduced capabilities (Intel)**

Initial scope: Discuss the proposals from [R2-2106462](file:///C%3A%5CData%5C3GPP%5CExtracts%5CR2-2106462_Summary%20AI%208.12.2.1%20v01.docx)

Initial intended outcome: Summary of the offline discussion with e.g.:

§  List of proposals for agreement (if any)

§  List of proposals that require online discussions

§  List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Thursday 2021-05-20 07:00 UTC

Initial deadline (for rapporteur's summary in R2-2106521): Thursday 2021-05-20 09:00 UTC

# Discussion

## Definition and capability signaling

### Capability design principle

**Summary in [20]on “how to capture RedCap capabilities” is cited as following:**

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| **Observation 1:** Regarding the capability design principle, the main difference between alternative 1 and 2 is whether to define an new independent container to contain all optional features for RedCap UEs;**Alternative 1** (to extend UE-NR-Capability using NCE for optional capabilities): 5 companies (vivo, Intel, Ericsson, CATT, Huawei)**Alternative 2**: Introduce an new container to contain all optional features:**Alternative 2.1** (introduce an new container to contain all optional features even if they are same (same value range) as legacy) : 2 companies (ZTE, CTC)**Alternative 2.2** (introduce an new container to contain all optional features except capabilities with same value range as legacy): 1 (Qualcomm)Accordingly to the WID [19], “o The existing UE capability framework is used; changes to capability signalling are specified only if necessary.”, Rapporteur considers Alternative 1 is more aligned with the guidance. However there is no clear majority on this. Considering the main difference between alternative 1 and 2 is whether to introduce a container to carry the RedCap UE capabilities, Rapporteur proposes:**Proposal 1:** [To discuss] Ask RAN2 to discuss whether to extend UE-NR-Capability (using non-critical extension) to include alternative 1) optional capabilities for Redcap UEs (5 support) or alternative 2) introduce an new independent container to contain all optional features for RedCap UEs (with alternative 2.1 even if some of them are same as legacy non-RedCap UE capabilities (2 support), or alternative 2.2 except capabilities with same value range as legacy (1 support)).  |

**Discussion point 1: how to capture RedCap capabilities (new container or not):**

**Option 1** (to extend UE-NR-Capability using NCE for optional capabilities): 5 companies (vivo, Intel, Ericsson, CATT, Huawei)

**Option 2**: Introduce an new container to contain all optional features:

**Option 2.1** (introduce an new container to contain all optional features even if they are same (same value range) as legacy) : 2 companies (ZTE, CTC)

**Option 2.2** (introduce an new container to contain all optional features except capabilities with same value range as legacy): 1 (Qualcomm)

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| **Company’s name** | **Option(s)** | **Comments, if any** |
| OPPO | Option 1 | If RedCap-specific capabilities are only a few, it seems that extending UE-NR-Capability would be sufficient. |
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**Summary in [20]on “RedCap capabilities design principle” is cited as following:**

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| [11] provided the full lists as below:

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| **Proposal 3b: Specify RedCap UE capabilities according to the principles below:****3-1: For RedCap UE’s mandatory without signalling features, which are optional or mandatory with capability signalling or mandatory without capability signalling but with different value(s) for non-RedCap UE (e.g. 20M bandwidth for FR1 and 100M bandwidth for FR2) or newly introduced in R17 (if any), clarify in TS 38.306 in the new section for RedCap UEs;****3-2: For RedCap UE’s optional features, which are mandatory without capability signalling for non-RedCap UEs (if any), or newly introduced in R17 for RedCap (e.g. HD-FDD, 1Rx/2Rx in some 4Rx mandatory band), add new UE capability signalling in TS 38.331 and capture them in the new section for RedCap UEs in TS 38.306;****3-3: For RedCap UE’s optional features, which are optional for non-RedCap UE but with different value (if any), either add new capability signalling or extend the legacy capability signalling, and also capture them in TS 38.306;****3-4: For the features not applicable to RedCap UE but optional supported or mandatory supported with capability signalling by non-RedCap UE, clarify in the definitions for parameters in TS 38.306 that “This capability is not applicable to RedCap UE” (e.g. CA, DC, 256QAM);****3-5: For the features not applicable to RedCap UE but mandatory without capability signalling supported by non-RedCap UE, clarify in TS 38.306 in the new section for RedCap UEs (e.g. bandwidths above 100MHz for FR2).** |

Rapporteur considers this as a good starting point, and would suggest:**Proposal 2** [To discuss] Ask RAN2 to discuss whether following capability design principle can be agreed or not: **Proposal 2.1** For RedCap UE’s mandatory without signalling features, which are optional or mandatory with capability signalling or mandatory without capability signalling but with different value(s) for non-RedCap UE (e.g. 20M bandwidth for FR1 and 100M bandwidth for FR2) or newly introduced in R17 (if any), clarify in TS 38.306 in the new section for RedCap UEs;**Proposal 2.2** For RedCap UE’s optional features, which are mandatory without capability signalling for non-RedCap UEs (if any), or newly introduced in R17 for RedCap (e.g. HD-FDD, 1Rx/2Rx in some 4Rx mandatory band), add new UE capability signalling in TS 38.331 and capture them in the new section for RedCap UEs in TS 38.306;**Proposal 2.3** For RedCap UE’s optional features, which are optional for non-RedCap UE but with different value (if any), either add new capability signalling or extend the legacy capability signalling, and also capture them in **TS 38.306;****Proposal 2.4** For the features not applicable to RedCap UE but optional supported or mandatory supported with capability signalling by non-RedCap UE, clarify in the definitions for parameters in TS 38.306 that “This capability is not applicable to RedCap UE” (e.g. CA, DC, 256QAM);**Proposal 2.5** For the features not applicable to RedCap UE but mandatory without capability signalling supported by non-RedCap UE, clarify in TS 38.306 in the new section for RedCap UEs (e.g. bandwidths above 100MHz for FR2). |

Rapporteur noticed that the design principle also mentioned examples, we should discuss the principle first without mentioning these examples, i.e.

***Proposal 2.1*** *For RedCap UE’s mandatory without signalling features, which are optional or mandatory with capability signalling or mandatory without capability signalling but with different value(s) for non-RedCap UEor newly introduced in R17 (if any), clarify in TS 38.306 in the new section for RedCap UEs;*

***Proposal 2.2*** *For RedCap UE’s optional features, which are mandatory without capability signalling for non-RedCap UEs (if any), or newly introduced in R17 for RedCap , add new UE capability signalling in TS 38.331 and capture them in the new section for RedCap UEs in TS 38.306;*

***Proposal 2.3*** *For RedCap UE’s optional features, which are optional for non-RedCap UE but with different value (if any), either add new capability signalling or extend the legacy capability signalling, and also capture them in* ***TS 38.306*** *in the new section for RedCap UEs* ***;***

***Proposal 2.4*** *For the features not applicable to RedCap UE but optional supported or mandatory supported with capability signalling by non-RedCap UE, clarify in the definitions for parameters in TS 38.306 that “This capability is not applicable to RedCap UE”;*

***Proposal 2.5*** *For the features not applicable to RedCap UE but mandatory without capability signalling supported by non-RedCap UE, clarify in TS 38.306 in the new section for RedCap UEs.*

**Discussion point 2: Do you support the RedCap capability design principle listed in above proposal 2 series?**

**Please justify your response if any.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | Yes |  |
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### Capabilities for RedCap UE

**Summary in [20]on “how to apply the capability design principle for RedCap specific capabilities” is cited as following:**

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| R2-2104927 Intel, R2-2105234 Ericsson and R2-2105634 Huawei also proposed how to design capabilities for them. **Summary how to apply the capability design principle for RedCap specific capabilities:** If the capability design principle in proposal 2 can be agreed. Rapporteur think it would be good to further discuss how to apply the principle for RedCap specific capabilities which we already know, and therefore propose:**Proposal 3:** [2nd priority topic ] If the capability design principle in proposal 2 is agreed, to further discuss how to apply the capability principle for following features: Maximum bandwidth (20M for FR1 and 100M for FR2)Minimum number of Rx branches (1 )Maximum number of DL MIMO Layers (1 DL MIMO layer for 1 RX and 2 DL MIMO layer for 2 Rx)Relaxed maximum modulation order (optionally support 256QAM for DL)Not support carrier aggregation, dual connectivityHD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.) |

Based on [11], how to apply the capability design principle (proposal 2 seriers) for RedCap specific capabilities is listed as below:

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| **Capability** | **Design principle** |
| Maximum bandwidth (20M for FR1 and 100M for FR2) | ***Proposal 2.1*** *For RedCap UE’s mandatory without signalling features, which are optional or mandatory with capability signalling or mandatory without capability signalling but with different value(s) for non-RedCap UE (****e.g. 20M bandwidth for FR1 and 100M bandwidth for FR2****) or newly introduced in R17 (if any), clarify in TS 38.306 in the new section for RedCap UEs;****Proposal 2.5*** *For the features not applicable to RedCap UE but mandatory without capability signalling supported by non-RedCap UE, clarify in TS 38.306 in the new section for RedCap UEs (****e.g. bandwidths above 100MHz for FR2****).* |
| Minimum number of Rx branches (1 ) | ***Proposal 2.2*** *For RedCap UE’s optional features, which are mandatory without capability signalling for non-RedCap UEs (if any), or newly introduced in R17 for RedCap* ***(e.g. HD-FDD, 1Rx/2Rx in some 4Rx mandatory band****), add new UE capability signalling in TS 38.331 and capture them in the new section for RedCap UEs in TS 38.306;* |
| Maximum number of DL MIMO Layers (1 DL MIMO layer for 1 RX and 2 DL MIMO layer for 2 Rx) | ? |
| Relaxed maximum modulation order (optionally support 256QAM for DL) | ***Proposal 2.4*** *For the features not applicable to RedCap UE but optional supported or mandatory supported with capability signalling by non-RedCap UE, clarify in the definitions for parameters in TS 38.306 that “This capability is not applicable to RedCap UE” (e****.g. CA, DC, 256QAM****);* |
| Not support carrier aggregation, dual connectivity | ***Proposal 2.4*** *For the features not applicable to RedCap UE but optional supported or mandatory supported with capability signalling by non-RedCap UE, clarify in the definitions for parameters in TS 38.306 that “This capability is not applicable to RedCap UE” (****e.g. CA, DC, 256QAM****);* |
| HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.) | ***Proposal 2.2*** *For RedCap UE’s optional features, which are mandatory without capability signalling for non-RedCap UEs (if any), or newly introduced in R17 for RedCap* ***(e.g. HD-FDD, 1Rx/2Rx in some 4Rx mandatory band),*** *add new UE capability signalling in TS 38.331 and capture them in the new section for RedCap UEs in TS 38.306;* |

**Discussion point 3: Do you agree the handling on RedCap specific capabilities listed in above table? Please indicate your comments/suggestions if any.**

**Note: Discussion point 3 depends on the outcome of discussion point 2.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | Yes |  |
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### Others

**Summary in [20]on “how the network is aware of RedCap UE” is cited as following:**

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| **Summary on how network is aware of RedCap UE:**Option 1 RedCap device type is indicated as part of the capability signalling.: 5 companies (Intel, Huawei, Ericsson, Samsung, ViVO)Option 2 Define a new IE specifically for RedCap UEs containing RedCap-specific capabilities. The IE is included in the signalling only by Redcap UEs.: 1 company (vivo)Option 3 The network identifies RedCap UEs based on identification solution (see Section 11.1), e.g. during Msg1, Msg3, MsgA, etc, (pending RAN1 conclusion). The identification is forwarded it to target gNB during handover: 2 companies (Ericsson, CMCC)Option 4: The network identifies RedCap UE based on the reported capabilities, assuming the identification can be done through RedCap-specific capabilities not used by non-RedCap UEs.Considering the new indication is clear solution, and can also handle the handover case. Rapporteur would suggest:**Proposal 4: [To agree]** [5/8] introduce an explicit capability to indicate when the UE is a RedCap UE (as per option 1). |

**Discussion point 4: Do you support the proposal 4 in the summary paper [20], i.e.** introduce an explicit capability bit to indicate RedCap UE in the UE capability when the UE is a RedCap UE (as per option 1).**? If not, please justify your response.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | Yes | This explicit bit can be used for network to do RedCap UE’s capability check. |
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**Summary in [20]on “the definition of RedCap UE type” is cited as following:**

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| 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. **R2-2105319 CATT**- 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 : **R2-2104910 VIVO, R2-2105160 ZTE, R2-2105234 Ericsson, R2-2105634 Huawei****Summary on definition of RedCap UE type:** Rapporteur would consider that further discussion is needed, and RAN2 could wait for RAN1 on this. **Proposal 5**: [2nd priority topic ] Postpone the discussion on the definition of RedCap UE type and wait for RAN1 input.  |

**Discussion point 5: Which option do you prefer**.**? Please justify your response.**

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| **Company’s name** | **Options** | **Comments, if any** |
| OPPO |  | Wait for RAN1 input. |
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**Summary in [20]on “**only one UE type is supported**” is cited as following:**

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| R2-2105160 clarified that only one UE type is supported based on the WID [19] and asked RAN2 to confirm.**Summary on the maximum number of RedCap UE type:** Rapporteur considers this as stage 3 details, but would be ok to clarify this. **Proposal 6**: [To agree ] Ask RAN2 to confirm that only one RedCap UE type is defined for both FR1 and FR2. |

**Discussion point 6: Do you support the proposal 6 in the summary paper [20], i.e.** only one RedCap UE type is defined for both FR1 and FR2.**? If not, please justify your response.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO |  | Maybe good to clarify the difference from “one RedCap UE type is defined per FR” since this was also not clear during RANP discussion. |
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## Constrain the use of RedCap

**Summary in [20]on “**Constrain the use of RedCap**” is cited as following:**

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| Following 4 options were captured in the TR:* **Option 1**: RRC Reject based approach, i.e. RAN can reject an RRC connection establishment attempt if the service the UE requests is not allowed for RedCap UEs**.**

**3 companies (CATT, Interdigital, CMCC)*** **Option 2**: Subscription validation (Note: SA2, CT1 confirmation is needed), i.e. RedCap UE identifies itself during its RRC connection establishment procedure; RAN then informs core network, which then decides whether to accept or reject UE’s registration/connection request.

**5 companies** **(Qualcomm, vivo, Intel, Ericsson, CMCC, CTC)*** **Option 3**: Verification of RedCap UE, i.e. Network performs capability match between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type

**9 companies (Qualcomm, OPPO, vivo, Intel, ZTE, Ericsson, LG, Interdigital, CTC)*** **Option 4**: Left up to network implementation to ensure RedCap UE uses intended services and/or resources.

**1 company (CATT)**For option 3, 6 companies (CMCC, LG, Ericsson, VIVO, OPPO, Intel) consider it as a network implementation. I.e., if the UE reported capabilities do not match RedCap type, the network may reject the UE or not configure corresponding capabilities. In addition, 5 companies think LS to SA2/CT1 is needed at least for option 2. **Proposal 7:** [To agree] [9/11]To prevent RedCap UEs from using capabilities not intended for RedCap UE, RAN2 to agree option 3, i.e. “Verification of RedCap UE, i.e. Network performs capability match between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type”.**Proposal 7.1:** [To agree] If the reported capabilities do not match the RedCap UE type, how network prevents its usage is left up to network implementation. For example, the network may reject UE or not configure non-RedCap UE specific configurations to the UE, e.g. CA, DC, etc.**Proposal 8:** [To discuss] Ask RAN2 to discuss whether option 1 (RRC reject based approach [3/11])) and/or option 2 (Subscription validation [5/11]) are needed to prevent RedCap UEs from using capabilities not intended for RedCap UE. .**Proposal 8.1:** [To discuss] If option 2 (Subscription validation) is confirmed as needed by RAN2, to consult SA2/CT1 whether there is any specification impact to perform subscription validation. |

**Discussion point 7: Do you support the proposal 7 and 7.1 in the summary paper [20], i.e.**

**Proposal 7:** [To agree] [9/11]To prevent RedCap UEs from using capabilities not intended for RedCap UE, RAN2 to agree option 3, i.e. “Verification of RedCap UE, i.e. Network performs capability match between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type”.

**Proposal 7.1:** [To agree] If the reported capabilities do not match the RedCap UE type, how network prevents its usage is left up to network implementation. For example, the network may reject UE or not configure non-RedCap UE specific configurations to the UE, e.g. CA, DC, etc.

**If not, please justify your response.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | Yes |  |
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**Discussion point 8: For option 1 -RRC Reject based approach, i.e. RAN can reject an RRC connection establishment attempt if the service the UE requests is not allowed for RedCap UEs.**

**Is option 1 needed? If yes, please justify your response.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | No |  |
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**Discussion point 9: For option 2 Subscription validation (Note: SA2, CT1 confirmation is needed), i.e. RedCap UE identifies itself during its RRC connection establishment procedure; RAN then informs core network, which then decides whether to accept or reject UE’s registration/connection request.**

**Is option 2 needed? If yes, please justify your response.**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | No |  |
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**Discussion point 9.1: If option 2 needed, should RAN2 send LS to consult SA2/CT1 whether there is any specification impact to perform subscription validation?**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
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## UE complexity reduction techniques for higher layers

**Summary in [20]on “**2.3 UE complexity reduction techniques for higher layers**” is cited as following:**

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| Companies ‘s views are shown as below:

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| Tdoc number | Company | Related proposals and views |  |
| R2-2105136 | Apple | **Proposal 1: The maximum number of DRBs supported is a mandatory with signaling capability and is provided as part of UE capability for RedCap devices. Range is FFS****Proposal 2: The support of 18-bit SN for PDCP is optional with capability signaling for RedCap UEs.****Proposal 3: The support of 18-bit SN for RLC AM mode is optional with capability signaling for RedCap UEs.****Proposal 4: RRC processing delay requirements for RedCap UEs can be different from legacy NR UEs. FFS on the actual values.**  |  |
| R2-2105539 | Spreadtrum | **Proposal 1: Support scalingFactor report for REDCAP UE, considering some additional smaller values or the REDCAP UE specific values to match the requirement of REDCAP UE use case better.**   |  |
| R2-2105634 | Huawei | **Proposal 6: Consider to reduce the number of DRBs mandatorily supported by RedCap UEs.** **Proposal 7: Consider to reduce the length of PDCP and RLC AM sequence number to be mandatorily supported for RedCap UE (e.g. mandatory 12-bit SN).****Proposal 8: Do not consider to further reduce the L2 buffer size calculated in TS 38.306.****Proposal 9: Do not consider to relax the RRC processing delay for RedCap UEs.** |  |

**Summary on 2.3 UE complexity reduction techniques for higher layers:**Based on the revised WID [19], the UE complexity reduction techniques for higher layers have not been listed as objective for the WI. It would be good for RAN2 to clarify whether it is in the scope or not before any discussion. **Proposal 9:** [To discuss] RAN2 to discuss whether the study of UE complexity reduction techniques for higher layers is or not in the scope for Rel-17. |
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**Discussion point 10: Is the study of UE complexity reduction techniques for higher layers in the scope for Rel-17?**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| OPPO | Yes |  |
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# Conclusion

To be added

# Reference

1. R2-2104774 Definition and constrained use of RedCap UEs Qualcomm Incorporated
2. R2-2104808 Discussion on constraining of reduced capabilities OPPO
3. R2-2104910 UE type definition and constraining for RedCap UEs vivo, Guangdong Genius
4. R2-2104927 RedCap UE capability and constraining of reduced capabilities Intel Corporation
5. R2-2105136 Resolution on some basic mandatory capabilities for RedCap UEs for faster product development Apple Inc
6. R2-2105160 Define and Constrain Reduced Capability for RedCap ZTE Corporation, Sanechips
7. R2-2105234 Definition of RedCap UE and first look on capability signaling Ericsson
8. R2-2105319 On Redcap UE capabilities and type CATT
9. R2-2105471 Capability for RedCap UEs and its early indication Samsung
10. R2-2105539 Discussion on L2 buffer size reduction for Redcap UE Spreadtrum Communications
11. R2-2105634 Definition of RedCap UE type and reduced capabilities Huawei, HiSilicon
12. R2-2105882 How to prevent RedCap UEs from using capabilities not intended for RedCap Ues LG Electronics UK
13. R2-2105910 On RedCap UE capabilities Nokia, Nokia Shanghai Bell
14. R2-2106053 Constraint of RedCap UE to intended use cases InterDigital
15. R2-2106098 RedCap UE capability and constraining of reduced capabilities Intel Corporation
16. R2-2106230 Discussion on the definition and constraining of reduced capabilities CMCC
17. R2-2106276 The capability and the constrain of RedCap UE China Telecommunications
18. TR 38.875
19. RP-210918, “Revised WID on support of reduced capability NR devices”
20. R2-2106462 Summary 8.12.2.1 - Definition of RedCap UE and reduced capabilities (Intel)