3GPP TSG RAN WG2 Meeting #116b-e R2-220xxxx

**Electronic meeting, January 17-25, 2022**

**Agenda item:** 8.12.2.1

**Source:** Intel Corporation

**Title:** Report of offline discussion [AT116bis-e][105][RedCap] Capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the report of following offline discussion:

* [AT116bis-e][105][RedCap] Capabilities (Intel)

Initial scope: Continue the discussion on open issues for RedCap capabilities, based on e.g. [R2-2200286](file:///C%3A%5CData%5C3GPP%5CExtracts%5CR2-2200286%20Open%20issues%20on%20RedCap%20capabilities.docx) and [R2-2200553](file:///C%3A%5CData%5C3GPP%5CExtracts%5CR2-2200553%20Definition%20and%20reduced%20capabilities%20for%20RedCap%20UE.doc)

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): Wednesday 2022-01-19 1300 UTC

Initial deadline (for rapporteur's summary in R2-2201737): Wednesday 2022-01-19 1500 UTC

Proposals marked "for agreement" in R2-2201737 not challenged until Thursday 2022-01-20 0300 UTC will be declared as agreed via email by the session chair (for the rest the discussion might continue in the GTW session).

# Annex: companies’ point of contact

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| **Company** | **Point of contact** | **Email address** |
| Intel Corporation | Yi Guo | Yi.guo@intel.com |
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# Discussion

## 3.1 Support of ANR

As discuss in [3]:

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| ANR is mandatory with capability signalling. The discussion in email discussion 105 was for RedCap UE whether it should be optional instead of mandatory with capability signalling.

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| **Summary on the Phase 2-Discussion point 2.1: Should ANR feature be optional for RedCap UE (instead of mandatory with capability signalling as for non-RedCap)?**21 companies provided inputs to this discussion point:* **ANR is optional for RedCap UE** is supported by 19 companies (Intel, ZTE, Apple, Huawei, OPPO, Spreadtrum, Qualcomm, Sierra Wireless, Futurewei, Samsung, Lenovo, KDDI, vivo, Sharp, Xiaomi, CATT, Sequans, ChinaTelecom, MediaTek)
* **ANR is mandatory for RedCap UE** is supported by 2 companies (Ericsson, LGE)

**Rapporteur**: There is clear majority on this 19/21. **Proposal 9.** **[To agree] [19/21] ANR feature is optional for RedCap UE; FFS on how to capture this in specification;** |

In offline 109, RAN2 continued the discussion on this:

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| **Summary on the Discussion point 2.1.3 on ANR: Should ANR feature be optional for RedCap UE (instead of mandatory with capability signalling as for non-RedCap)?**23 companies provided inputs to this discussion point:* **ANR is optional for RedCap UE** is supported by 13 companies (Intel, Sierra Wireless, Huawei, Spreadtrum, Qualcomm, Apple, CMCC, Futurewei, vivo, Sequans, MediaTek, LG, OPPO)

Huawei commented that “*There will be always non-RedCap UE to support ANR, since there is no RedCap only cell. ANR feature causes significant complexity for RedCap, which is not essential in the typical deployment.*”* **ANR is mandatory for RedCap UE** is supported by 7 companies (BT, Ericsson, Turkcell, Telecom Italia, Nokia, Deutsche Telekom, Vodafone)

BT mentioned that *ANR is a key feature for operators since it is required to deploy, to maintain and to optimize the network*. Ericsson is considering the scenario that NPN based RedCap only cell. * **No strong opinion:** 3 companies **(ZTE, CATT, NEC)**

**Rapporteur**: There is no clear majority on this. **Proposal 4, [To discuss] [13/23]** ANR feature is optional for RedCap UE; FFS on how to capture this in specification; |

We do not see the need to support RedCap only cell. The operator can use non-RedCap UE to get sufficient information on ANR. **Proposal 1:** **ANR feature is optional for RedCap UE;** |

**Discussion point 3.1-1: Companies are invited to provide view on whether ANR feature should be optional for RedCap UE?**

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| **Company’s name** | **Optional/Still mandatory?** | **Comments, if any** |
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## 3.2 Support of CHO

As discussed in [3]:

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| The issue was discussed in email discussion 105:

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| **Summary on the Phase 2-Discussion point 2.8: whether the features introduced by Rel-16 mobility, DAPS handover and Conditional Pscell change are supported by RedCap UE?** 20 companies provided inputs to this discussion point.* All companies agreed that DAPS and CAPC cannot be supported.
* But 8 companies (ZTE, Huawei, Spreadtrum, Futurewei, Lenovo, vivo, Xiaomi, MediaTek) do not see the problem to support CHO for RedCap UEs.

**Proposal 15 [To agree] [20/20] DAPS and CAPC related capabilities are not applicable for RedCap UE; [8/20] FFS on CHO. FFS on how to capture this in the specification;** |

During the email discussion, one company commented that “*considering the motivation of CHO (i.e. robustness especially for high frequency), we do not see the actual need for RedCap UE*”. To our understanding, CHO is anyway an optional feature. If it is complex to some RedCap UEs, then those RedCap UEs do not need to support it. But we do not see any technical reason on why we need to forbid the RedCap UE to support this. **Proposal 2: CHO related capabilities are applicable for RedCap UEs (understanding that CHO is already defined as an optional feature). “FFS on CHO” can be removed.**  |

**Discussion point 3.2-1: Companies are invited to provide view on whether CHO related capabilities are applicable for RedCap UEs?**

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| **Company’s name** | **Applied/Not supported?** | **Comments, if any** |
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## 3.3 How can network identify RedCap UE based on capability

As discussed in [3]:

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| RAN1 also discussed this issue and has agreed to introduce an explicit capability bit to indicate the support of RedCap [7] as

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| Features | Index | Feature group | Components | Need for the gNB to know if the feature is supported | Mandatory/Optional |
|  28. NR\_redcap | 28-1 | RedCap UE | 1. Maximum FR1 RedCap UE bandwidth is 20 MHz.2. Maximum FR2 RedCap UE bandwidth is 100 MHz.3. Early indication of RedCap UE in Msg.1 for 4-step RACHFFS whether to add any other basic features for RedCap UE | Yes | Optional with capability signalingRedCap UE must indicate this FG is supported |

Therefore RAN2 can confirm RAN1 agreements, and the capability can be captured in capability Rapporteur’s CRs. **Proposal 5: RAN2 confirms RAN1 agreement to introduce explicit bit to indicate the support of RedCap. The capability will be captured in Capability Rapporteur’s Mega CRs;**  |

**Discussion point 3.3-1: Companies are invited to provide view on whether RAN2 can confirm RAN1 agreement to introduce explicit bit to indicate the support of RedCap. The capability will be captured in Capability Rapporteur’s Mega CRs?**

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| **Company’s name** | **Confirm RAN1 agreements/do not agree?** | **Comments, if any** |
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As discussed in [3]:

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| It is also related to the description in TS38.306 running CR [8] where the mandatory reduced capabilities for a RedCap UE is defined', i.e. “Early indication of RedCap UE in Msg.1 for 4-step RACH” should be added.

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| RedCap UE is the UE with reduced capability:* The maximum bandwidth is 20 MHz for FR1, and is 100 MHz for FR2;
* The maximum mandatory supported DRB number is 8;
* The mandatory supported PDCP SN length is 12 bits while 18 bits being optional;
* The mandatory supported RLC AM SN length is 12 bits while 18 bits being optional;
* 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported;
* Support of early indication of RedCap UE in Msg.1 for 4-step RACH;
* CA, MR-DC, DAPS, CPAC and IAB ( i.e., the RedCap UE is not expected to act as IAB node) related UE features and corresponding capabilities are not supported by RedCap UEs. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap UEs same as non-RedCap UEs, unless indicated otherwise.
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**Proposal 6: To add “Support of early indication of RedCap UE in Msg.1 for 4-step RACH” 'as part of the basic component of RedCap UE in 4.2.xx** **RedCap Parameters of TS38.306 running CR;**  |

**Discussion point 3.3-2: Companies are invited to provide view on whether “-Support of early indication of RedCap UE in Msg.1 for 4-step RACH;” should be captured in 4.2.xx RedCap Parameters of TS38.306 running CR as one of the basic component of RedCap UE? i.e.**

RedCap UE is the UE with reduced capability:

* The maximum bandwidth is 20 MHz for FR1, and is 100 MHz for FR2;
* The maximum mandatory supported DRB number is 8;
* The mandatory supported PDCP SN length is 12 bits while 18 bits being optional;
* The mandatory supported RLC AM SN length is 12 bits while 18 bits being optional;
* 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported;
* Support of early indication of RedCap UE in Msg.1 for 4-step RACH;
* CA, MR-DC, DAPS, CPAC and IAB ( i.e., the RedCap UE is not expected to act as IAB node) related UE features and corresponding capabilities are not supported by RedCap UEs. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap UEs same as non-RedCap UEs, unless indicated otherwise.

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| **Company’s name** | **Agree the TP/Do not agree?** | **Comments, if any** |
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## 3.4 Half-duplex FDD capability

As discussed in [3]:

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| RAN1 also discussed this issue and has agreed to introduce a capability bit to indicate the support of Half-duplex FDD operation type A [7] as

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| 28. NR\_redcap | 28-3 | Half-duplex FDD operation type A for RedCap UE | 1. Half-duplex FDD operation (instead of full-duplex FDD operation) type A for RedCap UE | Yes | Optional with capability signaling |

Therefore RAN2 can confirm RAN1 agreements, and the capability can be captured in capability Rapporteur’s CRs based on RAN2 agreements:**For Rel17 NR UE caps:** * Aim to Work on mega CRs (one mega CR for TS38.306 and one for TS38.331) to incorporate all RAN1/RAN4 feature groups. ​There could be exceptions, case by case.
* RAN2 should only implement the feature groups from the RAN1 and 4 feature list without any FFS (no highlighted yellow, [] and marked as FFS/TBD) into the CRs. Also Caps that are dependent on FFS Caps should not be implemented.

**Proposal 7: RAN2 confirms RAN1 agreement to introduce capability bit to indicate the support of Half-duplex FDD operation type A. The capability will be captured in Capability Rapporteur’s Mega CRs;**  |

**Discussion point 3.4-1: Companies are invited to provide view on whether RAN2 can confirm RAN1 agreement to introduce capability bit to indicate the support of Half-duplex FDD operation type A. The capability will be captured in Capability Rapporteur’s Mega CRs; ?**

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| **Company’s name** | **Confirm RAN1 agreements/Do not agree?** | **Comments, if any** |
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## 3.5 Support 1 DL MIMO layer

As discussed in [3]:

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| In [3], Huawei, ZTE discussed whether “support 1 DL MIMO layer” is same as “not supporting DL MIMO”. To our understanding, the confusion came from the wording “If absent, the UE does not support MIMO on this carrier”. The UE should at least support 1 MIMO layer to receive PDSCH. Then we may clarify this in TS38.306, i.e. “If absent, the UE ~~does not~~ support 1 MIMO layer on this carrier.”.**Proposal 8: Change the field description of “*maxNumberMIMO-LayersPDSCH*” from “If absent, the UE does not support MIMO on this carrier” to “If absent, the UE supports 1 MIMO layer on this carrier.”**  |

[4] also discussed the issue as

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| One leftover from last RAN2 meeting on how to report the DL MIMO layer for RedCap is on the legacy field maxNumberMIMO-LayersPDSCH.

| ***maxNumberMIMO-LayersPDSCH***Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception. For single CC standalone NR, it is mandatory with capability signaling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. If absent, the UE does not support MIMO on this carrier. | FSPC | CY | N/A | N/A |
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Based on the current ANS.1 design, One MIMO layer seems different with the case of not supporting MIMO, since the UL MIMO layer IE has the value of “oneLayer” while can be absent.MIMO-LayersDL ::=   ENUMERATED {twoLayers, fourLayers, eightLayers}MIMO-LayersUL ::=   ENUMERATED {oneLayer, twoLayers, fourLayers}In addition, there is no RAN1 agreement to state that 1RX is mandatory but 2RX is optional. It means, in the RAN2 speciciation, there should be no implication on RedCap UE will support one layer by default.**Observation 2: It is not clear in the current specification on whether “supporting one DL MIMO layer” is same as “not supporting DL MIMO”.** **Observation 3: Even if the statement “*If absent, the UE does not support MIMO on this carrier*” causes some ambiguity on the *oneLayer* supporting, it is better not to further change/clarify the R15 and R16 specification anymore.****Observation 4: As endorsed in running CR, by copying the WID, capture “RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported” in the RedCap specific section in TS 38.306.**To avoid any clarification to R15/16 speciation, we should directly add “oneLayer” for RedCap. However, it is not backward compatible to add one value to the legacy IE MIMO-LayersDL, since there is no spare value left. In that case, add one new R17 IE for RedCap will be the clean design.**Proposal 4: Introduce new value “*oneLayer*” for RedCap DL MIMO layer reporting in R17, to avoid any clarification which may impact on R15 and R16 specification.** |

Therefore we could see 3 options:

**Option 1:** **Change the field description of “*maxNumberMIMO-LayersPDSCH*” from “If absent, the UE does not support MIMO on this carrier” to “If absent, the UE supports 1 MIMO layer on this carrier.”**

**Option 2:** **Introduce new value “*oneLayer*” for RedCap DL MIMO layer reporting in R17, to avoid any clarification which may impact on R15 and R16 specification.**

**Option 3: Do nothing;**

**Discussion point 3.5-1: Companies are invited to provide view on which option should be adopted in Rel-17 on how to indicate oneLayer for DL MIMO?**

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| **Company’s name** | **Option 1, Option 2, Option 3** | **Comments, if any** |
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## 3.6 Impact due to RAN1 LS

As discussed in [3]:

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| In RAN1 LS, RAN1 mentioned

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| The following Rel-15/16 UE features or capabilities are not applicable for Rel-17 RedCap UEs:1. Capabilities related to carrier aggregation (CA)
2. Capabilities related to dual connectivity (DC)
3. Capabilities related to UE bandwidths wider than 20 MHz in FR1 or wider than 100 MHz in FR2
4. Capabilities related to more than 2 UE Rx branches or more than 2 DL MIMO layers
5. Capabilities related to more than 2 UE Tx branches or more than 2 UL MIMO layers
 |

1-2 have been captured in TS38.306 running CR as* CA, MR-DC, DAPS, CPAC and IAB ( i.e., the RedCap UE is not expected to act as IAB node) related UE features and corresponding capabilities are not supported by RedCap UEs. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap UEs same as non-RedCap UEs, unless indicated otherwise.

However 3-5 are missing, and should be captured. **Proposal 9: To add capability limitation on BW, Rx/Tx branches and UL/DL MIMO layers as part of the basic component of RedCap UE in 4.2.xx** **RedCap Parameters of TS38.306 running CR, e.g.** * UE features and corresponding capabilities related to UE bandwidths wider than 20 MHz in FR1 or wider than 100 MHz in FR2, more than 2 UE Rx branches or more than 2 DL MIMO layers, more than 2 UE Tx branches or more than 2 UL MIMO layers, CA, MR-DC, DAPS, CPAC and IAB ( i.e., the RedCap UE is not expected to act as IAB node) ~~related UE features and corresponding capabilities~~ are not supported by RedCap UEs. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap UEs same as non-RedCap UEs, unless indicated otherwise.
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**Discussion point 3.6-1: Companies are invited to provide view on whether to add capability limitation on BW, Rx/Tx branches and UL/DL MIMO layers as part of the basic component of RedCap UE in 4.2.xx RedCap Parameters of TS38.306 running CR: as**

* UE features and corresponding capabilities related to UE bandwidths wider than 20 MHz in FR1 or wider than 100 MHz in FR2, more than 2 UE Rx branches or more than 2 DL MIMO layers, more than 2 UE Tx branches or more than 2 UL MIMO layers, CA, MR-DC, DAPS, CPAC and IAB ( i.e., the RedCap UE is not expected to act as IAB node) ~~related UE features and corresponding capabilities~~ are not supported by RedCap UEs. All other feature groups or components of the feature groups as captured in TR 38.822 [24] as well as capabilities specified in this specification remain applicable for RedCap UEs same as non-RedCap UEs, unless indicated otherwise.

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| **Company’s name** | **Agree the TP/Do not agree?** | **Comments, if any** |
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As discussed in [3]:

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| Regarding PDSCH MIMO layer, RAN2 has agreed to reuse existing *maxNumberMIMO-LayersPDSCH* and therefore nothing to be changed, i.e. still per FSPC.

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| Agreement:* Inform RAN2 that “From RAN1 perspective, it would be enough to indicate the maximum number of PDSCH MIMO layers per band for RedCap UEs, but RAN1 notes that the type of FG2-3 (*maxNumberMIMO-LayersPDSCH*) is currently per FSPC and that it is up to RAN2 whether to signal per band or per FSPC”
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**Proposal 10: Existing field “maxNumberMIMO-LayersPDSCH ” is reused, i.e. it is still per FSPC for RedCap UE;** |

**Discussion point 3.6-2: Companies are invited to provide view on whether existing field “maxNumberMIMO-LayersPDSCH ” is reused for RedCap UEs, i.e. it is still per FSPC for RedCap UE;**

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| **Company’s name** | **No change, i.e. FSPC/change it as per band for RedCap UEs?** | **Comments, if any** |
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## 3.7 shortSN and am-WithShortSN for RedCap UEs

As discussed in [4]:

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| In RAN2#115-e meeting, it is already agreed that PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, to further clarify, we propose to add some supplementary descriptions under the field *shortSN* and am-*WithShortSN* in the 38.306 Running CR as follows: In the email discussion [Post115-e][108][RedCap] 38.306 Running CR (Intel), the running CR was endorsed with some leftover details. We propose to do further updates on the running CR as below proposals.**Proposal 5: To clarify in the field description of *shortSN* and *am-WithShortSN* that, RedCap UE should always report ”1” in TS 38.306 section 4.2.4 and 4.2.5.** |

**Discussion point 3.7-1: Companies are invited to provide view on whether to clarify in the field description of shortSN and am-WithShortSN that, RedCap UE should always report ”1” in TS 38.306 section 4.2.4 and 4.2.5.**

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| **Company’s name** | **Agree the clarification/Do not agree the change?** | **Comments, if any** |
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## 3.8 Inter-RAT mobility management

As discussed in [4]:

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| **Observation 5: The LTE coverage is an important backup for RedCap UEs considering the limitation of NR Redcap service coverage and NR coverage during the early deployment stage.****Observation 6: For the inter-RAT mobility from NR to LTE, the current cell reselection and handover mechanisms can be reused for RedCap UEs paired with LTE module.****Observation 7: For the inter-RAT mobility from LTE to NR, the source LTE cell** **cannot identify whether a UE is the RedCap type and does not have information on the RedCap-supporting of target NR cells.*** **Option 1**

If some information on whether the target NR cell supports RedCap can be provided to the RedCap UE before it starts to access the target cell, the incorrect handover procedure can be terminated as early as possible. Afterwards, the RedCap UE can perform e.g. RRC re-establishment in a RedCap-supporting NR cell or a LTE cell.A specific solution is that the target NR cell which supports RedCap adds a new indication in the RRC reconfiguration message sent to the UE during the handover procedure. Then after receiving the configuration generated by the target NR cell, the RedCap UE checks whether the new indication is included:* If the new indication is included, the target NR cell supports RedCap and the UE can continue the handover procedure as legacy;
* Else, the target NR cell is actually a legacy cell which does not support RedCap, thus the UE does not need to access the target cell and instead performs RRC re-establishment in a RedCap-supporting NR cell or a LTE cell.
* **Option 2**

The RedCap UE first performs handover as legacy without knowledge on the type of the target NR cell. Then the RedCap UE checks whether the target NR cell supports RedCap after synchronizing with the target cell and receiving the SIB1 of the target cell. A possible way is:* If the SIB1 broadcast by the target cell contains RedCap specific IFRI, the target NR cell supports RedCap and the UE can work in this cell later;
* Else, the target NR cell is actually a legacy cell which does not support RedCap, thus the UE can perform RRC re-establishment in a RedCap-supporting NR cell or a LTE cell.

Comparing the two options, Option 1 can prevent the RedCap UE from performing incorrect handover access to legacy NR cells but has certain spec impact; Option 2 has less spec impact but the RedCap UE can only determine whether the handover target is appropriate after synchronizing with the target NR cell.**Proposal 7: For the LTE to NR handover, if the RedCap UE finds the target NR cell is a legacy cell, the UE should trigger RRC re-establishment procedure. FFS on the spec impact.** |

**Rapporteur comments**: For handover scenario, the target gNB should check the UE capability before provides the configuration (accept handover ). However the legacy gNB cannot identify the RedCap UE, and therefore cannot reject the handover. But the configuration configured by the legacy gNB will very likely exceed the RedCap UE capability, and cannot be supported by the RedCap UE. Therefore the RedCap UE will trigger the reestablishment procedure as specified in TS36.331:

#### 5.4.3.5 Mobility from E-UTRA failure

The UE shall:

1> if T304 configured in the *MobilityFromEUTRACommand* message expires (mobility from E-UTRA failure); or

1> if the UE does not succeed in establishing the connection to the target radio access technology; or

1> if the UE is unable to comply with (part of) the configuration included in the *MobilityFromEUTRACommand* message; or

1> if there is a protocol error in the inter RAT information included in the *MobilityFromEUTRACommand* message, causing the UE to fail the procedure according to the specifications applicable for the target RAT (i.e. according to subclause 5.3.5.6 if the *targetRAT-Type* in the received *MobilityFromEUTRACommand* is set to *eutra*):

2> stop T304, if running;

2> if the *cs-FallbackIndicator* in the *MobilityFromEUTRACommand* message was set to *TRUE* or *e-CSFB* was present:

*3>* indicate to upper layers that the CS fallback procedure has failed;

2> revert back to the configuration used in the source PCell, excluding the configuration configured by the *physicalConfigDedicated*, *mac-MainConfig* and *sps-Config*;

2> if *MobilityFromEUTRACommand* concerned a failed inter-RAT handover from E-UTRA to NR and if the UE supports Radio Link Failure Report for Inter-RAT MRO NR:

3> store handover failure information in *VarRLF-Report* according to 5.3.5.6;

2> initiate the connection re-establishment procedure as specified in 5.3.7;

So question is, whether the issue can be addressed by existing approach? If not, how to handle this case?

**Discussion point 3.8-1: Companies are invited to provide view on whether handover from LTE to a legacy gNB for RedCap UE could be addressed by existing solution? If new solution is needed, please elaborate how it works.**

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| **Company’s name** | **New solution is needed/existing way is sufficient?** | **Comments, if any** |
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# Summary report and proposals

# Reference

1. R2-2111259 Preparation for Rel-17 UE capability Intel Corporation
2. R1-2112902 Rel17 RAN1 UE feature List
3. R2-2200286 Open issues on RedCap capabilities Intel Corporation
4. R2-2200553 Definition and reduced capabilities for RedCap UE Huawei, HiSilicon