3GPP TSG RAN WG2 Meeting #114 [Draft] R2-2106462

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

**Agenda item:** 8.12.2.1

**Source:** Intel Corporation

**Title:** Summary 8.12.2.1 - Definition of RedCap UE and reduced capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This document is to summarize the proposals from contributions submitted under 8.12.2.1 on Definition of RedCap UE and reduced capabilities. As clarified by Session chair, the focus should be on high level principles, as we will not be able to go into many detailed discussions about individual capabilities during this meeting.

# Discussion

## Definition and capability signaling

### Capability design principle

As captured in the TR [18], two capability design principle alternatives were considered in the SI phase:

|  |
| --- |
| the following capability design principle alternatives can be considered:Alternative 1:- The UE capability requirements for a RedCap device type, that are different from those for non-RedCap UEs, are listed in the specifications. That is:- Mandatory features for non-RedCap UEs that are not applicable for RedCap UEs.- Mandatory features for non-RedCap UEs that are optional for RedCap UEs.- Mandatory features for non-RedCap UEs that are supported for RedCap UEs but with different value.- Optional features for non-RedCap UE that are not applicable for RedCap UE.- Optional features for non-RedCap UE that are mandatorily supported for RedCap UE.For a RedCap device type, define new signalling fields in UE capability signalling for the features that are mandatory without capability signalling for non-RedCap UEs but are optional for Redcap UEs, or mandatory with capability signalling for non-RedCap UEs but with different value for RedCap UEs. Such new signalling is only applicable for RedCap UEs.Alternative 2:- Directly define the UE capabilities required for RedCap devices, including:- Mandatory features for RedCap UEs (defined in specification).- Optional features for Redcap UEs (introduce signalling fields in an independent container defined specifically for Redcap UE). |

Rapporteur would like to clarify the intention of Alternative 2 since based on companies’ contribution, seems companies may misunderstand it.

As discussed in RAN2#112, the proponent company clarified:

|  |
| --- |
| Besides, we would suggest to also list following option in the TR. The main difference is that, we don’t have to add clarification to each existing Non-Redcap UE capabilities. We can directly define what we need for Redcap UEs. We understand this is simpler and cleaner solution. Down selection between solutions can be done in WI phase. **Directly define the UE capabilities required for RedCap devices, including:** **---Mandatory features for RedCap UEs (defined in specification);** **---Optional features for Redcap UEs (introduce ignaling fields in an independent container defined specifically for Redcap UE).** These capabilities includes the mandatory features for non-RedCap UE, but optionally supported by RedCap UE, optional features for non-RedCap UE and also optionally supported by RedCap UE with same or different values. |

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;

Companies ‘s views are cited as below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Tdoc number** | **Company** | **Related proposals and views** | **Rapporteur comments** |
| R2-2104774 | Qualcomm | Alternative 1 plus or Alternative 2 plus?**Proposal 1. Define in specifications the set of mandatory features that all RedCap UEs shall support, as well as the set of features not supported by RedCap UEs at all. All other UE features are considered optional for RedCap UEs.****Proposal 2. RedCap UEs explicitly signal optional UE capabilities that they support in a new, independent container defined specifically for RedCap UEs**. **Proposal 3. If there are UE capabilities for which both RedCap and non-RedCap UEs support but have different range of values, they should be included in this RedCap-specific container.****Proposal 4. If there are UE capabilities that RedCap and non-RedCap UEs both support and have the same range of values, RedCap UEs signal them as legacy capability and do not include them in the RedCap-specific container.** | Rapporteur, it is not exactly same as alternative 2 since:1 capabilities with same value for RedCap and non-RedCap is not contained in RedCap specific container;2 The feature not supported by RedCap shall be defined in the specification;It is more like Alternative 1 + RedCap specific container for RedCap specific capabilities; |
| R2-2104910 | vivo | **Alternative 1****Proposal 1: The UE capability requirements for RedCap UEs, that are different from non-RedCap UEs, are listed in the specifications:*** + - * **Mandatory features for non-RedCap UEs that are not supported for RedCap UEs;**
			* **Mandatory features for non-RedCap UEs that are optional for RedCap UEs;**
			* **Mandatory features for non-RedCap UEs that are supported for RedCap UEs but with different value;**
			* **Optional features for non-RedCap UEs that are mandatorily supported for RedCap UEs;**
			* **FFS: Optional features for non-RedCap UEs that are not supported for RedCap UEs.**
 | Rapporteur: Looks same as alternative one except “FFS” |
| R2-2104927 | Intel | **Alternative 1****Proposal 1: RedCap specific mandatory features (i.e. maximum bandwidth of FR1, minimum number of Rx branches and maximum number of DL MIMO layers) are reflected by RedCap UE type, i.e. a separate capability is not introduced for them. Restricted value for RedCap UE shall be reflected in the description of RedCap device type in TS38.306.****Proposal 2: For RedCap specific optional features (i.e. minimum number of Rx branches, maximum number of DL MIMO layers and relaxed maximum modulation order), separate capabilities shall be introduced. Only RedCap UE can indicate the support of these capabilities.** **Proposal 3: For optional features for non-RedCap UE that are not allowed for RedCap UE, the RedCap RedCap UE cannot indicate the support of these capabilities. This should reflected in the description for corresponding capabilities in TS38.306.****Proposal 5: RedCap specific optional capabilities are grouped together by defining a new capability IE specifically for RedCap;** | Rapporteur: Additionally clarified how to capture them in the specification.  |
| R2-2105160 | ZTE | Alternative 2**Proposal 3: To adopt capability signaling solution in alternative 2, i.e. to introduce signalling fields for optional capabilities and mandatory capabilities with signaling in an independent container defined specifically for Redcap UE.** |  |
| R2-2105234 | Ericsson | Alternative 1Re-use the capability signaling of NR Rel-15. Introduce new capability parameters for capabilities which were mandatory without capability signaling for NR Rel-15 and which are optional for RedCap. Extend the value range of existing capability parameters where necessary. RedCap UE uses the existing capability signalling to indicate maximum supported channel bandwidth per band, and per carrier (i.e. in feature set per CC). The field descriptions are updated to allow RedCap UEs to indicate maximum 20 MHz (FR1) or 100 MHz (FR2).A RedCap UE uses the existing capability signalling to indicate maximum number of supported MIMO layers per carrier, and no new capability is needed.The existing capability maxNumberMIMO-LayersPDSCH is used for indicating both the number of Rx branches and supported number of DL MIMO layers.Existing capability signalling is updated so that RedCap UE can optionally signal support for 256QAM, and no new capability is needed.A new capability for HD-FDD is needed, the details can be discussed further when RAN1 has progressed in their work.  | Rapporteur, considered this as alternative 1 direction. Additionally clarified how to capture them in the specification. |
| R2-2105319 | CATT | Alternative 1?**Proposal 2 Based on the general guidance in the WID, the following is confirmed for Redcap capabilities definition and report** * **the UE capability transfer procedure as specified in TS 38.331 section 5.6.1 is reused,**
* **the structure of *UECapabilityInformation, UE-CapabilityRAT-ContainerList,* andencoding for capabilities for the supported RAT are reused**
* **UE-NR-Capabilityis extended (using non-critical extension) to include optional capabilities for Redcap UEs.**

**Proposal 3 New signaling or clarifications are introduced for the following cases on a case by case basis** * **‎Mandatory features for non-RedCap UEs that are not applicable for RedCap UEs.‎**
* **‎Mandatory features (with or without signalling) for non-RedCap UEs that are optional for RedCap UEs.‎**
* **‎Mandatory features f(with or without signalling) or non-RedCap UEs that are supported for RedCap UEs but with different ‎value.‎**
* **‎Optional features for non-RedCap UE that are not applicable for RedCap UE.‎**
* **‎Optional features for non-RedCap UE that are mandatorily supported for RedCap UE.‎**
 | Rapporteur consider this as Alternative 1 since UE-NR-Capability is extended uning NCE.  |
| R2-2105471 | Samsung | ?**Proposal 2: During normal capability exchange, UE indicates the actual reduced capabilities separately, and the reduced capabilities can be signalled only if UE indicates a RedCap UE type.** |  |
| R2-2105634 | Huawei | Alt 1**Proposal 2: RAN2 confirm to use the existing UE capability framework for RedCap (i.e. alternative 1 in the SI phase).****Proposal 3a: Add new section for RedCap UE in TS 38.306, to capture at least RedCap UE’s specific capabilities.****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).****Proposal 3c: RAN2 to discuss whether legacy UE’s mandatory features with capability signalling become optional features or maintain as mandatory with capability signalling for RedCap UE in R17.** |  |
| R2-2106276 | China Telecommunications | Alternative 2**Proposal 1: Define the UE capabilities required for RedCap devices separately: define mandatory features in specification and introduce independent container for optional features.**  |  |

**Summary on how to capture RedCap capabilities:**

**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:

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)).

[4], [7] and [11] further discussed the details on how to handle following scenarios:

- Mandatory features for non-RedCap UEs that are not applicable for RedCap UEs.

- Mandatory features for non-RedCap UEs that are optional for RedCap UEs.

- Mandatory features for non-RedCap UEs that are supported for RedCap UEs but with different value.

- Optional features for non-RedCap UE that are not applicable for RedCap UE.

- Optional features for non-RedCap UE that are mandatorily supported for RedCap UE.

[11] provided the full lists as below:

|  |
| --- |
| **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:

1. **[To discuss]** Ask RAN2 to discuss whether following capability design principle can be agreed or not:
	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;
	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. 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;
	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);
	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).

### Capabilities for RedCap UE

R2-2104927 Intel mentioned scenarios can be considered when design the capability signalling for RedCap.

|  |
| --- |
| At RAN2#112, the definition of RedCap UE capability was discussed and RAN2 agreed to the following:Agreements:1. RedCap UE capabilities can be categorized as:

• Min capabilities all RedCap UEs support (i.e. mandatory for RedCap UE) if identified; o FFS on whether some features are mandatory with signaling for RedCap UE, i.e. IOT bit;o (Note: RedCap UEs might have the same set of higher layer capabilities, however this is FFS in RAN2) • Optional capabilities (signaled explicitly)1. Following scenarios are considered when design the capability signaling for RedCap UE, but FFS on the details, e.g. what each category of features may include and on the applicability of the cases:

For the features that are mandatory for non-Redcap UEs: Case1: The Redcap UE mandatorily supports the feature with the same value;Case2: The Redcap UE mandatorily supports the feature, but with different value (e.g. bandwidth value);Case3: The Redcap UE optionally supports the feature;Case4: The Redcap UE does not support the feature at all. For the features that are optional for non-Redcap UEs: Case1: The Redcap UE does not support the feature at all.Case2: The Redcap UE supports the feature with different value;Case3: The Redcap UE supports the feature with the same value;Case4: The Redcap UE mandatorily supports the featureAs captured in the WID[19], RAN1 already agreed some capabilities that are matched to above scenarios:**For the features that are mandatory for non-Redcap UEs:****Case 2 The Redcap UE mandatorily supports the feature, but with different value:*** Maximum bandwidth of FR1 reduced to 20Mhz (compared with 40Mhz);
* Minimum number of Rx branches:
	+ For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1.
	+ For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1.
* Maximum number of DL MIMO layers:
	+ For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.

**Case3: The Redcap UE optionally supports the feature:*** Minimum number of Rx branches: The specification also supports 2 Rx branches for a RedCap UE in these bands.
* Maximum number of DL MIMO layers:
	+ For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported.
* Relaxed maximum modulation order:
	+ Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.

**For the features that are optional for non-Redcap UEs:** **Case1: The Redcap UE does not support the feature at all:*** Carrier aggregation, dual connectivity and wider bandwidths;
 |

R2-2105910 Nokia mentioned to confirm these capabilities as

|  |
| --- |
| **Proposal 1: RedCap UE shall not support carrier aggregation.****Proposal 2: RedCap UE shall not support dual connectivity.****Proposal 3: RedCap Maximum bandwidth of an FR1 RedCap UE during and after initial access is 20 MHz.****Proposal 4: RedCap Maximum bandwidth of an FR2 RedCap UE during and after initial access is 100 MHz.****Proposal 5: Functionality defined for RedCap UE shall not be implemented by non-RedCap UE** |

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:

1. **[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:
	1. Maximum bandwidth (20M for FR1 and 100M for FR2)
	2. Minimum number of Rx branches (1 )
	3. Maximum number of DL MIMO Layers (1 DL MIMO layer for 1 RX and 2 DL MIMO layer for 2 Rx)
	4. Relaxed maximum modulation order (optionally support 256QAM for DL)
	5. Not support carrier aggregation, dual connectivity
	6. HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.)

### Others

During SI phase, RAN2 concluded that the network should know whether the UE is a RedCap UE or not. But the solutions are still open.

|  |
| --- |
| The network should know whether the UE is a RedCap UE or not in order to handle UE capabilities properly (see also Section 11.1 on UE identification). The following options, which do not need to be mutually exclusive, can be considered for further analysis and down-selection:Option 1: RedCap device type is indicated as part of the capability signalling.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.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. 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.  |

Companies ‘s views are cited as below:

|  |  |  |
| --- | --- | --- |
| Tdoc number | Company | Related proposals and views |
| R2-2104910 | vivo | Option 1 or option 2**Proposal 2: In order to handle UE capability properly for network, a RedCap device type or new IEs containing capability signaling specific for RedCap UEs should be reported to the network. FFS during in UE capability report and/or early identification, if any.**  |
| R2-2104927 | Intel | Option 1**Proposal 4: RedCap device type is indicated as part of the capability signaling;** |
| R2-2105234 | Ericsson | Option 1 or option 3The network can identify a RedCap UE based on the early indication (if configured) and an explicit capability (not a type) indicating the UE is a RedCap UE.  |
| R2-2105471 | Samsung | Option 1**Proposal 1: During normal capability exchange, UE indicates a RedCap UE type by a new separate bit as specified in the WID.** |
| R2-2105634 | Huawei | Option 1**Proposal 4: A RedCap device type should be indicated explicitly as part of the capability signalling (even in the case** **a RedCap UE does not support any RedCap specific optional capability).**Proposal 5a: It should be ensured that source gNB only handover RedCap UE to a target gNB supporting RedCap UEs.Proposal 5b: Send LS to RAN3 to discuss the solution for Proposal 5a. |
| R2-2106230 | CMCC | Option 3**Proposal 1: the identification of the RedCap UEs during initial access could be considered to identify the device type of UE for network.** |

**Summary on how network is aware of RedCap UE:**

Option 1: 5 companies (Intel, Huawei, Ericsson, Samsung, ViVO)

Option 2: 1 company (vivo)

Option 3: 2 companies (Ericsson, CMCC)

Considering the new indication is clear solution, and can also handle the handover case. Rapporteur would suggest:

1. **[To agree]** [5/8] introduce an explicit capability to indicate when the UE is a RedCap UE (as per option 1).

Regarding the definition of RedCap UE type, following options were captured in the TR:

|  |
| --- |
| 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 |

Option 4: R2-2104910 VIVO, R2-2105160 ZTE, R2-2105234 Ericsson, R2-2105634 Huawei

Option 2: R2-2105319 CATT

**Summary on definition of RedCap UE type:** Rapporteur would consider that further discussion is needed, and RAN2 could wait for RAN1 on this.

1. **[2nd priority topic ]** Postpone the discussion on the definition of RedCap UE type and wait for RAN1 input.

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.

1. **[To agree ]** Ask RAN2 to confirm that only one RedCap UE type is defined for both FR1 and FR2.

## Constrain the use of RedCap

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.
* **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.
* **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
* **Option 4**: Left up to network implementation to ensure RedCap UE uses intended services and/or resources.

Companies ‘s views are cited as below:

|  |  |  |  |
| --- | --- | --- | --- |
| Tdoc number | Company | Related proposals and views | Rapporteur comments |
| R2-2104774 | Qualcomm | Prefer option 2 and 3;All 4 options involve CN enhancements;Send LS to SA2/CT1 on all options;**Proposal 5. Send a LS to SA2/CT1 to request an evaluation of the 4 options and study necessary enhancements to ensure constrained use of RedCap UEs.** |  |
| R2-2104808 | OPPO | Prefer Option 3:Down selection is needed for option 1 and 2 before triggering other groups for discussion.[Proposal 1From RAN2’s perspective, following solution can be taken to constrain reduced capabilities.](#_Toc71280125)- **Option 3**: Verification of RedCap UE. Network performs capability match between UE's reported radio capabilities and the set of capability criteria associated with UE's RedCap type.  | Mentioned in the paper, Option 3 could be up to network implementation |
| R2-2104910 | vivo | Prefer option 2 and 3;Send LS to SA2/CT1 on option 2;**Proposal 6: An LS is sent to SA2/CT1 to consult the details for constraining based subscription validation, if RAN2 agreed to consider option 2.** | Mentioned in the paper, Option 3 could be up to network implementation |
| R2-2104927 | Intel | Prefer option 2 and 3;Send LS to SA2/CT1 on option 2;**Proposal 6: To prevent RedCap UEs from using capabilities not intended for RedCap UE, RedCap UEs providing capabilities restricted for this kind of UEs (i.e. applicable only to non-RedCap UEs) may be blocked or rejected access by the network (i.e. network may perform capability match procedure between UE’s reported radio capabilities and RedCap UE type);****Proposal 7: To prevent RedCap UEs from using services not intended for RedCap UE, RedCap UEs requesting services restricted for this kind of UEs (i.e. applicable only to non-RedCap UEs) may be blocked or rejected access by the core network (i.e. core network may perform subscription validation, i.e. validates UE’s indication against its subscription plan, which includes information such as the set of services allowed for the RedCap UE);****Proposal 8: Send LS to SA2, CT1 to inform them about subscription validation, and ask them to confirm;** | Mentioned in the paper, Option 3, network may block/reject the RedCap UE to access the network if it provide capabilities restricted to non-RedCap capabilities.  |
| R2-2105160 | ZTE | Prefer option 3Send LS to SA2/CT1 on option 2**Proposal 6: To consult SA2/CT1 whether there is any specification impact to perform subscription validation.****Proposal 7: Verification of RedCap UE is performed based on RedCap specific container solution.** |  |
| R2-2105234 | Ericsson | Prefer option 2 and 3?The CN should be aware the UE is a RedCap UE during initial UE message to e.g. support subscription validation or differentiated charging, access control, or policy control.  | Mentioned in the paper, Option 3, network implementation, e.g. not configure non-RedCap configurations to RedCap UE; |
| R2-2105319 | CATT | Prefer option 1 and 4**Proposal 4 The following mechanisms (and their combinations) are sufficient to meet the objective on constraint of utilization of /for Redcap UE capabilities*** **RRC Reject based approach**
* **Left up to network implementation to ensure RedCap UE uses intended services and/or resources.**

**FFS on other possible mechanism.**  |  |
| R2-2105882 | LG | Prefer option 3**Proposal. Based on the UE capability information, the network prevents RedCap UEs using capabilities not intended for RedCap UEs.** | Mentioned in the paper, Option 3, not configure non-RedCap configurations to RedCap UE; |
| R2-2106053 | InterDigital | Option 1+option 3 if early identification is enabled, otherwise Option 3. **Proposal 1: RRC Reject based approach (Option 1) is baseline method to ensure RedCap UEs are used for intended use cases if early identification (i.e. msg1/msgA/msg3) is enabled.****Proposal 2: In addition to RRC Reject based approach, network may optionally verify RedCap UE via capability match (i.e. Option 1 + 3) after UE capability reporting.****Proposal 3: If early identification (i.e. msg1/msgA/msg3) is not enabled, verification of RedCap UE via capability match (i.e. Option 3) is baseline method to ensure RedCap UEs are used for intended use cases** |  |
| R2-2106230 | CMCC | Prefer option 1 and 2**Proposal 2: The RAN could check the RAN side capabilities, such as the number of UE Rx/Tx antennas or UE bandwidth. If the capability does not match the definition of reduced capability UE, the network could reject the UE with RRC rejection.** | Rapporteur: However based on the description of option 1 in the contribution, seems it fits into option 3 concept.  |
| R2-2106276 | China Telecommunications | Prefer option 2 and 3Send LS to SA2/CT1 on option 2;**Proposal 2: RAN2 consider the subscription validation so that the core network can make sure the RedCap device type matches the service subscription during registration.****Proposal 3: RAN2 send a LS to SA2 and CT1 to analyze the feasibility of the solutions involving core network.****Proposal 4: Verification of REDCAP UE capability can accepted as a complement.** |  |

**Summary on constraining the use of RedCap:**

Based on the contributions (11 companies discussed this issues), companies’ view are shown as below:

Option 1: 3 companies (CATT, Interdigital, CMCC)

Option 2: 5 companies (Qualcomm, vivo, Intel, Ericsson, CMCC, CTC)

Option 3: 9 companies (Qualcomm, OPPO, vivo, Intel, ZTE, Ericsson, LG, Interdigital, CTC)

Option 4: 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.

1. **[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”.
	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.
2. **[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. .
	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.

## UE complexity reduction techniques for higher layers

As captured in the TR [18]:

|  |
| --- |
| The following UE complexity reduction techniques for higher layers have been discussed in RAN2:- Reduction of the maximum number of DRBs which UE needs to mandatorily support.- Reduction of L2 buffer size. According to the calculation in TS 38.306, with peak data rate reductions, L2 buffer requirements for RedCap UEs are implicitly reduced accordingly. Benefits and feasibility of further reduction requires evaluation in normative phase if it is to be considered.- SN in PDCP and RLC is 18-bits, and the size could be reduced depending on which features RedCap UEs support, if a clear benefit in such reduction is identified.- The gain of relaxing RRC processing delay requirements was not studied and requires further evaluation in normative phase if it is to be considered.These UE complexity reduction techniques for higher layers have not been explicit objectives during the study and would require further evaluation during the normative phase if they are to be considered. |

Companies ‘s views are shown as below:

|  |  |  |  |
| --- | --- | --- | --- |
| 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.

1. **[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.

# Conclusion

**The observations captured are the following:**

**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;

**The proposals captured are the following:**

**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)).

**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).

**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:

**Proposal 3.1.** Maximum bandwidth (20M for FR1 and 100M for FR2)

**Proposal 3.2.** Minimum number of Rx branches (1 )

**Proposal 3.3.** Maximum number of DL MIMO Layers (1 DL MIMO layer for 1 RX and 2 DL MIMO layer for 2 Rx)

**Proposal 3.4.** Relaxed maximum modulation order (optionally support 256QAM for DL)

**Proposal 3.5.** Not support carrier aggregation, dual connectivity

**Proposal 3.6.** HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.)

**Proposal 4.** **[To agree]** [5/8] introduce an explicit capability to indicate when the UE is a RedCap UE (as per option 1).

**Proposal 5.** **[2nd priority topic ]** Postpone the discussion on the definition of RedCap UE type and wait for RAN1 input.

**Proposal 6.** **[To agree ]** Ask RAN2 to confirm that only one RedCap UE type is defined for both FR1 and FR2.

**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.

**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.

# 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”