**3GPP TSG-RAN WG2 Meeting #112 electronic R2-200xxxx**

**Elbonia, Nov 2nd – 13th 2020**

**Agenda item:** 8.12.2.1

**Source:** Intel Corporation

**Title:** Report of [Post111-e][913][REDCAP] Definition and constraining of reduced capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This contribution provides report for RAN WG2 email discussion:

* [Post111-e][913][REDCAP] Definition and constraining of reduced capabilities (Intel)

Scope: Continue to discuss the UE capability framework, how to define and constrain reduced capabilities, addressing the open issues and discussing potential solutions

Intended outcome: email discussion summary

 Deadline: Oct 15th , 2020

Rapporteur proposes to divide the discussion in two phases:

**Phase 1**: Based on the contributions in last meeting, and the agreements from RAN1:

* To collect companies’ view on potential scope/issues of the email discussion;
* To collect additional issues/solutions;

Deadline: Sep 30th

**Phase 2**: Companies are invited to provide views on the issues/solutions collected/clarified in phase 1.

Deadline: Oct 15th

To make it easier to find the correct contact delegate in each company for potential follow-up questions, the rapporteur encourages the delegates who provide input to provide their contact information in this table:

|  |  |
| --- | --- |
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# Discussion

## Phase 1

### How to define the reduced capabilities

Based on [3], RAN2 discussed the issues on how to define and constrain reduced capabilities and agreed [2]:

Agreements:

1. At least for device type identification and access restriction (including initial access), the network needs to know whether the UE is redCap UE or not. FFS on whether based on explicit or implicit signalling.
2. The existing UE capabilities framework is used as baseline to indicate the capabilities of a RedCap UE (this does not imply anything on the reporting of the device type, if the need for a device type will be agreed)
3. The number of device types should be minimised, to reduce market fragmentation, and introduced only where essential to control UE accesses and differentiate them from legacy R15/R16 and non-Redcap R17 UEs, (e.g. number of Tx/Rx antennas, maximum supportable BW, etc.). The exact composition of the set of L1 capabilities of the device type can be discussed by RAN1
4. Discuss in normative phase on whether to signal (and in case how) a Device type and its associated capabilities (the reduced set of capabilities) is captured in specifications, and whether device type is indicated as part of UE capability;

Regarding the open issue “*FFS on whether based on explicit or implicit signalling.*”, for device type identification and access restriction, Rapporteur believes it should be discussed or resolved once the solutions on device type identification is clear.

For the issue how to define the reduced capabilities, RAN2 have agreed “*2. The existing UE capabilities framework is used as baseline to indicate the capabilities of a RedCap UE*”, however the details are still missing. During the offline discussion in [3], following is mentioned:

* *“We agree to consider the current signalling structure as a baseline, but we think the capabilities restriction for the defined device type should be specified very clearly in the specification (maybe separate section in TS38.306) to avoid unnecessary complexity for the UE and gNB to implement corresponding capabilities, including:*
	+ *Mandatory/Minimum set of capabilities for the defined device type*
	+ *Capabilities (or specific values for certain capability) that only apply to the defined device type*
	+ *Capabilities (or specific values for certain capability) not apply to the defined device type”*
* “*For example, as part of the current NR capabilities we have:*
	+ *Min capabilities all UEs support (not signaled explicitly)*
	+ *Optional capabilities (signaled explicitly)*

*Similarly, for RedCap we expect:*

* + *Min capabilities all RedCap UEs support (only identifier needs to be signaled)*
	+ *Optional capabilities (signaled explicitly)”*

On top of high level agreements “*2. The existing UE capabilities framework is used as baseline to indicate the capabilities of a RedCap UE*”, it would be good to further clarify:

* Whether similar to current NR non-RedCap UE capabilities, RedCap UE capabilities can also be categorized as:
	+ *Min capabilities all RedCap UEs support (i.e. mandatory for RedCap UE);*
	+ *Optional capabilities (signaled explicitly)*

**Question 1-1: Do companies agree that similar to current NR non-RedCap UE capabilities, RedCap UE capabilities can also be categorized as:**

* **Min capabilities all RedCap UEs support (i.e. mandatory for RedCap UE) if identified;**
* **Optional capabilities (signaled explicitly)**

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| **Company** | **Yes/No** | **Remark**  |
| Intel | Yes |  |
| Apple | Yes | We agree there would be atleast some aspects all RedCap UEs are expected to support mandatorily (atleast needed for initial aspects) and so we cannot define capabilities for all of these. |
| Sharp | Yes | The mandatory capabilities without signaling for non-RedCap UE but mandatory capabilities with signaling for RedCap UE are also possible. |
| OPPO | Yes | According to RAN1 agreements, at least 20MHz bandwidth for FR1 is mandatory for all RedCap UEs. |
| ZTE | Yes | We agree Redcap UE capabilities can be categorized as “mandatory ones” and “optional ones”, and this provides flexibility to market planning and product implementation. But we are wondering whether we need to define “min capabilities” with different values for different Redcap types. E.g. differentiate FR1, FR2.  |
| NEC | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Spreadtrum | Yes |  |
| LGE | Yes |  |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| Qualcomm | Yes |  |
| Samsung | Yes |  |
| Futurewei | Yes |  |
| vivo | Yes |  |
| Nokia | Yes |  |
| CATT | Yes |  |

**Summary:**

15 companies provided inputs, and all of them agreed the question.

1 company commented that mandatory with signalling is also possible.

1 company commented whether different RedCap type UEs may support different value for mandatory features.

Rapporteur would suggest:

**Proposal 1: RedCap UE capabilities can be categorized as:**

* **Min capabilities all RedCap UEs support (i.e. mandatory for RedCap UE) if identified;**
	+ **FFS on whether some features are mandatory with signaling for RedCap UE, i.e. IOT bit;**
	+ **FFS on whether different RedCap type UEs may support different value for mandatory features;**
* **Optional capabilities (signaled explicitly)**

Question in phase 2:Do companies agree the proposal 1?

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| --- | --- | --- |
| **Company** | **Yes/No** | **Remark**  |
| Intel | Yes |  |
| vivo | Yes with comments | Besides, we think the following further clarification is also needed on top of the first bullet:FFS whether different RedCap type UEs may support different sets of mandatory capabilities, e.g. half duplex may be mandatory for type 2, but it may be optional for type 1 (just an example, detail is up to RAN1 decision).  |
| NEC | Yes |  |
| OPPO | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes |  |
| Huawei, HiSilicon | Yes with comments | For the second FFS, we understand the number of RedCap type and the value for mandatory features should be decided in RAN1, so it would be better to add “up to RAN1 decision” in the proposal. |
| CATT | Yes |  |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Ericsson | Yes but | Like HW comments above, there is no agreement on number of UE types, which second FFS bullet seem to assume, thus this should be clarified.  |
| MediaTek | Yes but | We agree with others that there is no agreement on number of UE types which the second FFS bullet seems to assume. This needs to be clarified.Even if RAN1 agree to introduce different UE types, there can still be a single set of capabilities that all RedCap UEs mandatorily support, with further optional capabilities to differentiate between UE types.  |
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For current NR non-RedCap UE capabilities, the minimum capabilities, e.g. mandatory bandwidth, e.g. are not signalled, and may not be applied for RedCap UE (depends on RAN1 agreements). How to handle such capabilities?

**Question 1-2: How to handle non-RedCap UE’s mandatory capabilities without signaling if they are not applied for RedCap UE?**

* **Alt 1: (As commented in the offline discussion [3]), The minimum UE capability requirements for a RedCap device type, that are different from those for non-RedCap UEs, are defined in the specifications, and only the RedCap device type may be indicated as part of the capability signaling.;**
* **Alt 2 [7]:**  **For a RedCap device type, define new capability signaling fields for the features that are mandatory w/o capability signaling for non-RedCap UEs but are optional or not supported for the RedCap device type.**
* **Alt 3: The minimum UE capability requirements for a RedCap device type, that are different from those for non-RedCap UEs, are defined in the specifications. That is:**
	+ **Mandatory features for non-RedCap UE that are not supported for RedCap UE;**
	+ **Mandatory features for non-RedCap UE that are optional for RedCap UE;**

**For a RedCap device type, define new signaling fields in UE Capability for the features that are mandatory w/o capability signaling for non-RedCap UEs but are optional for Redcap UEs.**

**In addition, the network needs to know whether the UE is RedCap UE or not in order to know how to handle UE capabilities (that is, when these fields are not included, it should be possible to differentiate whether it is because it is a non-Redcap UE or because it is not supported by a RedCap UE).**

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| **Company** | **Alt 1, Alt 2 or others** | **Remark**  |
| Intel | Alt 3 | For mandatory features w/o capability signalling supported by non-RedCap UE, there are 3 scenarios:Scenario 1 it is not supported for RedCap UE;Scenario 2 it is optional for RedCap UE;Scenario 3 it is still mandatory supported for RedCap UE;To our understanding:Alt 1 cannot work well for scenario 2 since it cannot indicate optional features (mandatory for non-RedCap UE)Alt 2 cannot work well for scenario 1 since currently the absence of these capability means “mandatory”.To solve the problem, we may combine alt 1 and 2 as:**To address scenario 1:**The minimum UE capability requirements for a RedCap device type, that are different from those for non-RedCap UEs, are defined in the specifications. That is:o Mandatory features for non-RedCap UE that are not supported for RedCap UE;o Mandatory features for non-RedCap UE that are optional for RedCap UE;**To address scenario 2:**For a RedCap device type, define new signaling fields in UE Capability for the features that are mandatory w/o capability signaling for non-RedCap UEs but are optional for Redcap UEs.In addition, the network needs to know whether the UE is RedCap UE or not in order to know how to handle UE capabilities (that is, when these fields are not included, it should be possible to differentiate whether it is because it is a non-Redcap UE or because it is not supported by a RedCap UE). |
| Apple | Modified version of Alt-3  | We agree with the ambiguity that can arise from the scenarios and different interpretations. In addition to the Alt-3, for the fields that are mandatory to non-RedCap UEs, but optional to RedCap UEs, we also need to distinguish what the absence of a field means: * Whether the RedCap UE supports the mandatory functionality like the non-RedCap UEs
* Whether the RedCap UE does not support this functionality at all.

We think, this needs to be clarified for the new capability signaling we add for RedCap UEs. It can be done for each of the fields, are as a group…but we think it might be better to do for each of such capabilities. |
| Sharp | Alt3 | The mandatory capabilities without signaling for non-RedCap UE but mandatory capabilities with signaling for RedCap UE are also possible and need to be defined in the specifications. |
| OPPO | Alt3 with comments | We are fine with alt3 to cover both cases only if they are confirmed by RAN1:o Mandatory features for non-RedCap UE that are not supported for RedCap UE;o Mandatory features for non-RedCap UE that are optional for RedCap UE;For the moment, we think the first case has been confirmed, e.g. mandatory bandwidth. The second case is still up to RAN1. |
| ZTE | Modified version of Alt3 | In our understanding, for the fields that are mandatory for non-Redcap UEs, there are following cases: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 Case1, 2 and 4, we think they can be defined in specification. For case 3, as indicated in Alt-3, new signalling field can be introduced for Redcap UEs.  |
| NEC | Alt 3 | At this moment, we share the views from Intel. On the other hand, we are wondering how/whether RAN2 should go into details before knowing which capabilities (e.g. among legacy mandatory capabilities) are not supported by the RedCap UEs. Probably better to wait for RAN1 progress?  |
| Huawei, HiSilicon | Alt-3 with comment | We are globally fine with the proposed principles in Alt-3.In addition, to reduce the complexity for the UE and the network to implement the UE capabilities, we think optional features for non-RedCap UE that are not supported for RedCap UE also need to be specified in the specifications, e.g. capabilities related to DC does not apply to RedCap UE. |
| Spreadtrum | Agree with Huawei |  |
| LGE | Alt-1 or Alt-3 |  |
| Ericsson | Modified Alt 3 / new alt | We suggest to first study which capabilities would fall into which category (cf. Intel scenarios) before jumping into conclusions on exact definitions and solutions. For example, is it clear there are some mandatory (w/o signaling) capabilities which would be optional for RedCap? As the existing mandatory features/capabilities are not listed in TS 38.306, we are hesitant to introduce such just for RedCap purpose, if that is the intention in Alt-3. We should look into how e.g. mandatory LTE features were handled when Cat-M1/M2 were introduced. Preferably the RedCap UE definition lists or explains which mandatory features are not supported. [Rapp] It is the intention of alt 3, i.e. lists which mandatory features of non-RedCap UE are not supported for RedCap UE, etc.In general, we have agreed to discuss the details of capability signaling in normative phase, and typically capabilities are discussed late in normative phase. For the study phase and TR we can explain the issues, do a study of the existing capabilities/features (e.g. which would be optional) and present the different possible solutions. |
| MediaTek | Alt 1 (or 3) i.e. identifier + optional capabilities | If RedCap UEs provide a RedCap identifier (associated with the new set of mandatory features for RedCap UEs), the network would interpret capability fields in Scenario 1 and Scenario 2 differently for RedCap and non-RedCap UEs. For now, we should first look at which set of features fall in scenarios 1/2/3 before going into signaling design details. |
| Qualcomm | Part of Alt 3 | We can support the principles behind Alt 3. Regarding the last statement in Alt 3, i.e. “network needs to know whether the UE is RedCap UE or not in order to know how to handle UE capabilities”, we think UE needs to indicate it is a RedCap for network to ensure its constrained use and that indication will be sent in connection request before UE capability signaling. Therefore, RedCap type indication does not need to be included in UE capability signaling.Lastly, we share similar views with companies above that it is a bit too early to discuss this level of details in capability signaling, especially not knowing yet what each category of features may include. |
| Samsung | Alt. 3 in general | We share the view with Qualcomm, and we agree with principles of Alternative 3 in general, but it is too early to discuss this level of details in capability signaling. |
| Futurewei | Alt. 3 in principle | The actual forms and details of capability signaling need to be finalized after more progress are made on the mandatory and optional features of Redcap UE.As it is possible that the Redcap type needs to be indicated to network before UE capabilities are sent, Redcap type may not be a part of UE capability signaling.  |
| vivo | Alt1, Alt3 | In General, we are fine with Alt.1 + Alt.3.If RedCap UEs have the same the mandatory capability for non-Redcap UEs (with the same value or different values), it could be defined in the specification. If RedCap UEs optionally support the mandatory capability for non-Redcap UEs, it could be indicated by capability signaling. If RedCap UEs don’t support the **mandatory/optional** capability for non-Redcap UEs, it could also be defined in the specification. In this way, the network can know how to handle UE capabilities (that is, when these fields are not included, it should be possible to differentiate whether it is because it is a non-Redcap UE or because it is not supported by a RedCap UE). Before make the decision, we suggest further details need to wait from RAN1, i.e. whether any mandatory capability which is mandatory for non-Redcap UEs is not supported or optionally supported by Redcap UEs. Otherwise, we cannot confirm whether all the above cases are valid.  |
| Nokia | Alt.3 in principle | Exact wording/definition can be discussed further. |
| CATT | Alt.3 with comments | We can agree on general level Alt.3, but there are some aspects that need to be clarified. For example, redcap UE type may already be known by network before capability report (as mentioned already by some), and also that there might be more than one redcap UE types for which the capability handling may be different.Then we feel that some of the details can be left to normative phase. |
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**Summary:**

15 companies provided inputs.

Alt 1: 2 companies (MediaTek, LG)

Alt 3: 15 companies with comments;

Regarding the scenarios, most companies would like to consider:

For the features that are mandatory for non-Redcap UEs, there are following cases:

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.

1 company would like to consider the below scenario:

*For case 3, we also need to distinguish what the absence of a field means:*

* *Whether the RedCap UE supports the mandatory functionality like the non-RedCap UEs*
* *Whether the RedCap UE does not support this functionality at all.*

3 company would like to consider:

*Optional features for non-RedCap UE that are not supported for RedCap UE also need to be specified in the specifications, e.g. capabilities related to DC does not apply to RedCap UE.*

1 company commented that case 3 needs the confirmation from RAN1; 1 company commented the details of cases may need to wait for RAN1 progress.

5 company would like to study which capabilities would fall into which category (cf. Intel scenarios) before jumping into conclusions on exact definitions and solutions.

Rapporteur would suggest:

**Proposal 2: 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:**

For the features that are mandatory for non-Redcap UEs, following scenarios are considered:

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;

 For Case 3, what the absence of a field means:

* + Whether the RedCap UE supports the mandatory functionality like the non-RedCap UEs
	+ Whether the RedCap UE does not support this functionality at all.

Case4: The Redcap UE does not support the feature at all.

For the features that are optional for non-Redcap UEs, following scenario is considered:

Case1: The Redcap UE does not support the feature at all.

Do companies agree the proposal 2?

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| **Company** | **Yes/No** | **Remark**  |
| Intel | Yes |  |
| vivo | Yes with comment | In our understanding, the above case 1, 2, and 4 can fully cover the following part for Case 3: *For Case 3, what the absence of a field means:* * + *Whether the RedCap UE supports the mandatory functionality like the non-RedCap UEs*
	+ *Whether the RedCap UE does not support this functionality at all.*

Thus, we suggest to remove this part for case 3.  |
| NEC | Yes |  |
| OPPO | Yes with comments | For case 3, how does the absence of the field means RedCap UE supports the functionality if it is already optionally present?Or is the intention as below?*For Case 3, ~~what~~ the presence/absence of a field means:* * + *~~Whether~~ the RedCap UE supports the mandatory functionality like the non-RedCap UEs*
	+ *~~Whether~~ the RedCap UE does not support this functionality at all.*
 |
| Samsung | Agree with OPPO | Perhaps rapporteur would confirm, but I guess OPPO's clarification is the intention of the rapporteur? If then, we are fine with the Proposal 2. |
| Nokia | Agree with Oppo | It is far simpler to consider presence/absence of a field to indicate support/not support of a feature rather than implicit behavior. |
| Huawei, HiSilicon | Yes with comment | Agree with vivo, fine to remove the part “*For Case 3, what the absence of a field means:…*” for case 3. |
| CATT | Yes, with comments | Some comments on the following part*For the features that are optional for non-Redcap UEs, following scenario is considered:* *Case1: The Redcap UE does not support the feature at all.*This case may not impact the signalling, e.g., the case can be realized by the absence or the value of the optional filed. We think it can be simpler, i.e., a feature is either mandatory or optional for redcap UE. [ZTE] We think this relates to the scenario we described in Question1-6, about whether to disallow Redcap UE to report some high-end capabilities, Otherwise, the Redcap type may be various. In terms of how “not supported at all” is handled this may also depend on how many redcap UE types can considered. More specifically, if there are more than one types, then for a feature that is originally mandatory for non-redcap UE, there may be e.g., Type 1 redcap UE: Feature A is optionalType 2 redcap UE: Feature A is not supported…Maybe it can be explicitly captured in spec that for type 2 redcap UE the capability for Feature A is NOT included. But if the support for Feature A (optional or not supported at all) are all the same for the redcap UE types then the optional signalling can be used without much issue?On the other hand, if the above case is considered then do we also need to cover the case when redcap UE mandatorily supports a feature that is optional for non-redcap UE? |
| ZTE | Yes with comments | We share the comment from vivo, it is ok to remove following part from case 3:*For Case 3, what the absence of a field means:* * + *Whether the RedCap UE supports the mandatory functionality like the non-RedCap UEs*
	+ *Whether the RedCap UE does not support this functionality at all.*

Once case1,2,4 are defined in specification, then for case3, absence of the field will directly mean “Not supported” of the feature. |
| Lenovo | Yes | Agree with vivo. The case 3 could be removed. |
| Ericsson | Yes but | Agree with above comments on that the subcases for case 3 are not needed and additionally would be stage-3 signaling details. What does it mean to consider only the case a feature is not supported by RedCap UE for optional features for non-RedCap NR UEs? Shouldn’t we eventually also consider optional features and check whether existing signaling can be re-used, or if we would need additional values (like case 2 for mandatory features).  |
| MediaTek | Yes with comments | Limit to cases 1 to 4 without the subcases.Agree with Ericsson that the subcases for case 3 are unnecessary. Interpretation of presence/absence of fields will be decided when the stage-3 signaling details are being discussed, and the individual fields to be signaled are known.Also agree with CATT that optional features for non-RedCap UEs that RedCap UEs do not support may not impact capability signaling. |
|  |  |  |

For the Alt3, based on the scenario mentioned above, it can be modified as:

* **The minimum 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 UE that are not supported for RedCap UE;**
	+ **Mandatory features for non-RedCap UE that are optional for RedCap UE;**
	+ **Optional features for non-RedCap UE that are not supported for RedCap UE;**

**For a RedCap device type, define new signaling fields in UE Capability for the features that are mandatory w/o capability signaling for non-RedCap Ues but are optional for Redcap Ues.**

Rapporteur consider it can be the capability design principle for RedCap UE although some companies would like to consider it in normative phase.

Question in phase 2: Do companies agree the above design principle for RedCap UE?

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| --- | --- | --- |
| **Company** | **Yes/No** | **Remark**  |
| Intel | Yes |  |
| vivo | Yes with comment | Besides, we think the following case should also be listed in the specifications as we discussed above:o Mandatory features for non-RedCap UE that are mandatorily supported for RedCap UE; |
| NEC | Yes | as conclusion (recommendation?) of Study Item. Anyway further detail is to be discussed in normative phase. Then, if RAN2 finds a fundamental problem, this may/can be revisited.On comment from vivo above, our understanding is “they” are not listed as there is no difference from non-RedCap UE by default, while no objection, if majority wants.. |
| OPPO | Yes with comments | Not sure if below two are contradictory?* **The minimum 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 UE that are not supported for RedCap UE;**
	+ **Mandatory features for non-RedCap UE that are optional for RedCap UE;**
	+ **Optional features for non-RedCap UE that are not supported for RedCap UE;**

**For a RedCap device type, define new signaling fields in UE Capability for the features that are mandatory w/o capability signaling for non-RedCap Ues but are optional for Redcap Ues.**If we define new ignaling fields for these features, do we still need to list those in the spec? |
| Samsung | Yes | Regarding OPPO’s comment, perhaps rapporteur’s intention of the first case is mainly for the mandatory with capability signalling, but rapporteur can clarify. |
| Nokia | Yes, but | We think it is important also to clarify if all the mandatory features **without** capability signalling also shall be supported by all Redcap UE’s. Then for the mandatory with capability signalling, this can be marked on case by case basis? |
| Huawei, HiSilicon | Yes with comment | As the capability for a RedCap UE that are **different** from those for non-RedCap Ues are listed, we think the Case2 above (The Redcap UE mandatorily supports the feature, but with different value) should be included:* + - * Mandatory features for non-RedCap UE that are mandatorily supported for RedCap UE with different value;

Moreover, after some more thinking, we wonder if the following case needs to be added. We are not sure if there is the case but it seems hard to preclude it now.o Optional features for non-RedCap UE that are mandatorily supported for RedCap UE. |
| CATT | Yes, with comments | Basically OK with the principle. See our comments on the part of “not support at all” in the previous question.  |
| ZTE | See comments | Seems the title “the minimum UE capability requirement” is somewhat contradict to the third bullet:* **Optional features for non-RedCap UE that are not supported for RedCap UE;**

We understand the details can be discussed during WI phase. For study phase, we can focus on finding possible solutions.The current Alt3 is to figure out how to clarify the capability for Redcap Ues from existing capabilities/features. In this case, we need to discuss case by case “whether a feature is applicable to Redcap or not”Since the Redcap UE with reduced capability is supposed to support a smaller group of capabilities, maybe another possible solution is to simply list or “pick out” the capabilities that are required for Redcap Ues, and then define whether each capability should be mandatory or optional for Redcap. This can be done regardless of the feature is mandatory for non-Redcap or not. And all optional capabilities required for Redcap UE, they can be defined in an independent container. In summary, the solution can be:**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).**  |
| Lenovo | Yes |  |
| Ericsson | Yes but details to be agreed in WI.  | We’d like to repeat our earlier comment on that it would be best to understand what all features we have for RedCap, which of these are mandatory and which are optional features etc before any down-scoping. Thus, also agree with HW on possible categories which are not currently listed in above proposals. Once we understand what the exact RedCap capabilities are, it will be easier to see e.g. whether all can be bundled behind one indication and whether there are some optional capabilities, and what the signaling solution should be in such cases.For the possible new capability signaling (e.g. NR features mandatory w/o capability signaling), it needs to be clear it only considers RedCap UEs and not legacy UEs. Also, most (if not all?) of the cases being discussed are similar to what we have for LTE-M and similar principles can be re-used.  |
| MediaTek | To be agreed in WI | We prefer not to make an early decision on signalling details without first knowing what information needs to be signalled, as such decisions can hinder rather than help progress during the WI. Once we know what the RedCap capabilities are, we can make a clear judgement on the signalling framework.As an example, we may not need to do anything in the specifications to address ‘*Optional features for non-RedCap UE that are not supported for RedCap UE*’.For now, we see the relevant scenarios as listed out in the earlier question as sufficient for the SI phase. |
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Some contributions [8], [9], discussed whether multiple reduced capability sets should be supported. Rapporteur would suggest to leave it to RAN1 since it is tightly related to the issue “the number of device type”.

**Question 1-3: Any additional issues need to be addressed in the email discussion on how to define the reduced capabilities?**

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| **Company** | **Issues** |
| Intel | As discussed in Question 1-2, Alt 3, the network needs to know whether the UE is RedCap UE or not in order to know how to handle UE capabilities (that is, when these fields are not included, it should be possible to differentiate whether it is because it is a non-Redcap UE or because it is not supported by a RedCap UE). But the question is how?We see below options, and this should be discussed in the email discussion. **Option 1:** RedCap device type is indicated as part of the capability signaling**Option 2:** Define a new IE specifically for RedCap Ues containing these additional Redcap specific capabilities that is included only by Redcap Ues.**Option 3:** The network obtains the RedCap based on identification solution during initial access, and forwards it to target during Handover. |
| Apple | Regarding comment by Intel, we think op-2 is simpler, and this would be added as a non-critical extension, so easier to address the gNBs which have not implemented RedCap. We can bunch all the RedCaps Ues into a struct, or add extensions in diff areas of the capability. If done correctly, Op-2 can cover Op-1’s functionality.We also think the target Gnb has to implement RedCap, to serve RedCap Ues. |
| Sharp | Depends on the discussion on identification. If there is a solution for identification, we can use the information for UE capability anyway. |
| OPPO | We think option 1 and 2 mentioned by Intel are needed after RAN1 confirms the two cases in Question 1-2. The final decision would be pending RAN1 input. |
| ZTE | Regarding the question raised by Intel, seems we have made agreement that it will be discussed in WID phase?

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| 4. Discuss in normative phase on whether to signal (and in case how) a Device type and its associated capabilities (the reduced set of capabilities) is captured in specifications, and whether device type is indicated as part of UE capability; |

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| Huawei, HiSilicon | Agree with the issue raised by Intel, i.e. how does the network know whether the UE is RedCap UE. We are fine to discuss the listed options in this email discussion. |
| Spreadtrum | Maybe we can discuss this issue after the definition of device type. |
| Ericsson | Note that early identification is also being discussed in another context as well. The details we have agreed to discuss further during the normative phase.  |
| MediaTek | Agree with the issue raised by Intel and the set of options for discussion. |
| Qualcomm | We prefer Option 3, as RedCap need to identify itself during connection setup, e.g. for the purpose of ensure RedCap is only used for intended use cases. |
| Samsung | We are also fine to discuss the issue raised by Intel, and prefer both options 1 and 3. |
| Futurewei | We also think it is related to Redcap identification, and option 3 seems to be simpler and cleaner.We are also fine to leave the detailed design of capability signaling to WI phase. |
| Vivo | In general, we are fine with option 1 and option 2. For option 3, it is related to another discussion on early indication. We should avoid the duplicated discussion. But we prefer to wait more progress on the device type and associated capabilities before making any decision here.  |
| Nokia | Network needs to identify the UE is REDCAP UE. |

**Summary:**

Regarding the issue raised by Intel, 12 companies provided inputs.

* + - * companies (Futurewei, ZTE, Ericsson) would like to discuss the details in WI phase;
			* companies (Futurewei, Qualcomm, Sharp) mentioned it is related to identification solution during setup procedure, i.e.option 3.

It would be good to check companies’ view on the options although it is related to other discussion.

As discussed in Question 1-2, Alt 3, the network needs to know whether the UE is RedCap UE or not in order to know how to handle UE capabilities (that is, when these fields are not included, it should be possible to differentiate whether it is because it is a non-Redcap UE or because it is not supported by a RedCap UE). But the question is how?

We see below options:

**Option 1:** RedCap device type is indicated as part of the capability signaling

**Option 2:** Define a new IE specifically for RedCap Ues containing these additional Redcap specific capabilities that is included only by Redcap UEs.

**Option 3:** The network obtains the RedCap based on identification solution during initial access, and forwards it to target during Handover.

**Question in phase 2: which option is prefer to let the network know how to handle the UE capabilities based on RedCap or non-RedCap?**

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| **Company** | **Option 1, 2, 3 or others** | **Remark**  |
| Intel | Option 1/2 | Option 2 is anyway needed since it is cleaner to group RedCap specific capabilities together, from specification perspective; But the problem is that the RedCap UE may not support any optional features, i.e.nothing inside the RedCap capability IE, and then whether the UE still needs to contain the empty IE or not. If yes, then same as option 1, and we have to specify that the RedCap UE must contain such high level IE. Option 3 is simper for the identification of the RedCap UE during setup procedure, but then the network has to forward the RedCap UE indication to target during Handover if we do not support option 1. Option 1 is clean solution since the target can know the RedCap UE type based on capability instead of the additional field in internode message. |
| vivo | Option 1/2 | Option 1 is a simple solution. Network could identify whether the UE is RedCap UE or not. Option 2 can also implicitly achieve the same target for option 1, i.e. functionally cover option 1. Besides, option 2 with a separate group of Redcap specific capabilities will make the specification clearer and more readable. Besides, we think the down-selection (either one or both) on these options can be made after more progress on Redcap type and associated capabilities. Both option 1/2 can be captured in TR in study item phase.  |
| NEC | Option 3 | we assume firstly the network can identify the RedCap during initial access and not sure whether anything is necessary further. Probably once RAN2 progress on how to identify the RedCap, then reconsider this issue further. |
| OPPO | Option 1/2 | As replied in Q 1-3, we think option 1 and 2 are useful to support below two cases.o Mandatory features for non-RedCap UE that are not supported for RedCap UE;o Mandatory features for non-RedCap UE that are optional for RedCap UE; |
| Samsung | Options 1/2 and part of 3 | As indicated by many companies, UE has to indicate its capability during initial access (i.e. early indication; Option 3), but this should also be delivered as a normal capability exchanges (Option 1/2) to handle other scenarios (e.g. handover). We do not agree the following procedure in Option 3 '*forwards it to target during Handover*'. |
| Nokia | Option 1 and 2 | This is more Stage-3 detail but as part of Capability Reporting the UE can indicate a ASN.1 container whose presence tells the network this is a REDCAP UE. The additional capabilities can be part of this container.We don’t understand what “initial access” has got to do with “handover”. That is why we haven’t provided any view on the topic. We understand that after security is activated, the capabilities can be sent to the target node for handover purposes. That principle cannot be changed in our view. |
| Huawei, HiSilicon | Option 1 | Option 1 is simple and feasible for all cases. Option 2 seems feasible only in case that there exist additional Redcap specific capabilities. If no more Redcap specific capability is introduced, Option 2 is not needed.Besides, for handover procedure, Option 1/2 is not enough considering the case that the source gNB supports RedCap feature but the target gNB is a legacy gNB, the target gNB cannot comprehend the RedCap related parameters in the UE capability signalling. Thus, additional solution may be needed to address this issue. |
| CATT | See comments | This discussion also relates to the email #914.A few comments on this part. Firstly, option 3 is related to thread #914, and in our view it depends on R1 output. Secondly, it is so far not very clear whether in the initial access phase, the redcap UE types can be known by network. More specifically, it may be that network only knows it is a redcap UE but the exact type. Then whether option 1 is needed actually depends on whether the capability handling for different redcap UE types are different.Then, regarding option 1 vs 2 it may be too early to discuss given there are too many flowing pieces. Last but not least, option 2 basically groups some capabilities in a new IE, but it seems possible that those capabilities are still based on existing IEs but with necessary modification? This can be discussed later as well.In short we feel it is too early to discuss all the details. Maybe we can first agree on some high level principles and leave others to later stage, as agreed in the last meeting‎*1.‎ Discuss in normative phase on whether to signal (and in case how) a Device ‎type and its associated capabilities (the reduced set of capabilities) is ‎captured in specifications, and whether device type is indicated as part of UE ‎capability;‎*  |
| ZTE |  | Option 3 is related to the discussion in [914]. We prefer to discuss this after more progress on device type, and UE identification during initial access. So we suggest to discuss this issue later, e.g. during WI phase.  |
| Lenovo |  | It is related to initial access and RAN1, we prefer to discuss it later. |
| Ericsson | Too early to decide | Largely agree with CATT. The solution has dependencies on the actual feature set and other decisions prior to this level of detail. This is also clear from above replies, e.g. if there are no optional capabilities then Option 1 and 2 seem to be the same. If there is no early indication then Option 3 doesn’t make sense etc. Thus, the options can be captured in the TR with pros/cons especially as the descriptions in this email discussion are not exact enough (cf. Nokia comment).  |
| MediaTek | Options 1, 2 (can also be left to WI) | We see options 1 and 2 as potential capability signalling solutions. However, as indicated in an earlier response, we are also ok to leave stage-3 signalling details to the WI phase. |
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### Constraining of reduced capabilities

How to ensure the RedCap UE is only used for intended use cases were discussed in [3]-[6]. Following potential solutions were mentioned:

* **Option 1 [5]**:

*One potential problem could be when a RedCap UE requests a service that does not match the RedCap UE type. This would be similar to if e.g. an NB-IoT UE requested a video call to be set up. RAN can already reject an RRC connection establishment attempt e.g. based on the establishment cause provided in Msg3 or through higher layer mechanisms.*

RAN can reject an RRC connection establishment attempt for a RedCap UE if the service the UE requested is not allowed for the RedCap UE. That is, the RAN needs to identify whether the UE is a RedCap UE or not, and be aware of the requested service, e.g. based on the cause value or other ways.

Note, the details of identification should be discussed in the email discussion [Post111-e][914][REDCAP] UE identification and access restrictions (Huawei).

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| * + **Opt. 1**: During Msg1 transmission, e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble partitioning.
	+ **Opt. 2**: During Msg3 transmission.
	+ **Opt. 3**: Post Msg4 acknowledgment.
		- **E**.g., during Msg5 transmission or part of UE capability reporting.
	+ **Opt. 4:** During MsgA transmission (subject to support of if 2-step RACH)
	+ Other options are not precluded.
	+ Note: This study intends to establish feasibility of, and pros and cons for the identified options from RAN1 perspective, without any intention of down-selection without guidance from RAN2.
 |

* **Option 2 [6]: subscription validation**

During RRC connection setup, UE indicates it is a RedCap UE to core network, e.g.

• UE includes this indication in its NAS signaling message to core network; or

• UE informs this indication during its RRC connection establishment procedure to RAN; RAN then informs core network of UE’s RedCap type in its Initial UE Context message to core network.

After network receives UE’s RedCap indication, it validates UE’s indication against its subscription plan, which includes information such as the set of services allowed for the UE. Based on the outcome of this validation, network then decide whether to accept or reject UE’s registration request. For example, network may reject UE if UE indicates RedCap but its subscription does not include any RedCap-specific services.

* **Option 3 [6]. Verification of RedCap UE**

Network can additionally perform capability match procedure between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type, to prevent a hacked or misconfigured UE from falsely reporting as a RedCap UE.

 **Option X:**

In Phase 1, companies are invited to provide clarifications on the options as above, and add additional options if any.

**Question 1-4: Any comments on the wording of the options described as above?**

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| **Company** | **Remark** |
| ZTE | **On option1:**One potential problem could be when a RedCap UE requests a service that does not match the reduced UE capabilities.We think it is more appropriate to use “reduced device type” instead of “reduced UE capabilities” , we understand the intention is that RAN can obtain the device type and corresponding minimal requirement during RRC setup procedure, then service rejection can be triggered if a certain cause value is not supported for the RedCap type. However, RAN has not received UE capabilities at RRC setup procedure, thus using reduced device type seems more accurate.*[Rapp] updated to “RedCap UE type”.* **On option2:**During RRC connection setup, UE indicates it is a RedCap UE to core network, e.g. • UE includes this indication in its NAS signaling message to core network; core network then informs RAN of UE’s RedCap type; or• UE includes this indication in its RRC connection establishment message to RAN; RAN then informs core network of UE’s RedCap type in its Initial UE Context message to core network.We understand both RAN and CN can obtain the Redcap type information, RAN obtains via Uu interface identification/capability reporting, and CN obtains via NAS signalling (subscription information). Thus for the red sentence in first bullet, it is unclear why CN will inform RAN of UE’s Redcap type, does it imply that RAN should double check whether the Redcap type obtained from RAN matches the one forwarded by CN? In our understanding, this “double check” can be performed by CN, and CN can reject the UE when mismatch happens, this is covered by the second bullet. So can company clarify the red sentence in first bullet? Otherwise, we prefer to remove it. [Rapp] Tend to agree the comments, suggest to remove the sentence. In addition, for the red sentence in second bullet, since we haven’t concluded whether explicit indication will be used in RRC message, maybe it is more appropriate to modify it as:“UE informs~~includes~~ this indication during~~in~~ its RRC connection establishment procedure~~message~~ to RAN”[Rapp]Updated.  |
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Question in phase 2: Do companies agree the updated options listed above?

Note: the intention is to agree the wording of options, and then we can capture them in the TR;

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| **Company** | **Yes/No** | **Remark**  |
| Intel | Yes |  |
| vivo | Yes | All options can be considered by now. Further decision can be made in WI phase.  |
| NEC | Yes |  |
| OPPO | Yes |  |
| Samsung | Yes |  |
| Nokia |  | It should be network behavior to either provide or not provide a service based on the UE capability. |
| Huawei, HiSilicon | Yes |  |
| CATT | Yes |  |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Ericsson | Yes | Can be captured in the TR. Also further options do not need to be precluded. |
| MediaTek | Yes |  |
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**Question 1-5 Any additional options for the network to ensure the RedCap UE is only used for intended use cases?**

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| **Company** | **Additional options** |
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**Question 1-6 Any other issues need to be addressed in the email discussion on the constraining of reduced capabilities?**

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| **Company** | **Issues** |
| ZTE | Whether all the optional capabilities defined for non-RedCap UE are applicable to RedCap UE? In our view, there are two alternatives:* Alt1: All the optional capabilities defined for non-RedCap UE are applicable to RedCap UE. In this case, the RedCap UE is allowed to support the “high end” capability based on the capability signalling, which may extend the scenarios of RedCap UE if it is allowed by the subscription information (e.g. low-end mobile phone).
* Alt2: Only limited optional capabilities defined for non-RedCap UE are applicable to RedCap UE. In this case more discussion are needed to understand which legacy optional capability are allowed for RedCap UE.

If Alt2 is preferred, regarding the capability signaling, we think it might be easier to introduce a new container for Redcap UEs, only includes the capabilities that are applicable to Redcap Ues. [Rapp] It is related to Huawei’s comments in question 1-2, but ok to check companies’ view.  |
| Nokia | This must be on case by case basis. We cannot make general assumption that all optional capabilities defined for non-REDCAP Ues also apply to REDCAP UE(s). |
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Question in phase 2:

Whether all the optional capabilities defined for non-RedCap UE are applicable to RedCap UE? There are two alternatives:

* Alt1: All the optional capabilities defined for non-RedCap UE are applicable to RedCap UE. In this case, the RedCap UE is allowed to support the “high end” capability based on the capability signalling, which may extend the scenarios of RedCap UE if it is allowed by the subscription information (e.g. low-end mobile phone).
* Alt2: Only limited optional capabilities defined for non-RedCap UE are applicable to RedCap UE. In this case more discussion are needed to understand which legacy optional capability are allowed for RedCap UE.

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| **Company** | **Alt 1/ Alt 2, others** | **Remark**  |
| Intel |  | More discussions are needed. But tend to agree, not all optional capabilities defined for non-RedCap UE are applicable to RedCap UE.  |
| Vivo |  | We also think it is too early to decide by now. More discussion on the reduced capabilities is needed. Our initial thinking is that Alt2 may be more reasonable, e.g. DC, short TTI, etc. features may not be supported by Redcap Ues. But not sure whether RAN1 have enough time to check all the optional features for non-Redcap Ues. Anyway, it is up to the feature discussion in work item phase.  |
| NEC |  | should be discussed in normative work. |
| OPPO |  | Too early to decide. |
| Samsung |  | We also think that it is too early to decide. |
| Nokia |  | This must be on case by case basis. We cannot make general assumption that all optional capabilities defined for non-REDCAP Ues also apply to REDCAP UE(s). Of course REDCAP specific capabilities need to be isolated away in separate place to ensure they don’t conflict with non-REDCAP Ues. |
| Huawei, HiSilicon | Alt 2 | For the time being, we think at least capabilities related to DC does not apply to RedCap UE. But it needs further discussions whether there are some other capabilities that is not supported for RedCap UE but optional for non-RedCap UE. Such detailed capabilities can be discussed further. |
| CATT |  | Agree that this can be discussed in normative phase. |
| ZTE |  | We agree more discussion is needed, details can be discussed during WI phase.  |
| Lenovo |  | Agree that more discussion is needed in normative phase. |
| Ericsson | Too early / Alt 2  | Too early to make any commitment but likely not all optional features would not make sense in RedCap context as brought up by some other replies.  |
| MediaTek |  | It would be difficult to make a general assumption on this topic, and therefore agree with others that it is too early to decide |
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# Summary

To be added:

# Reference

[1] Chairman's Notes RAN1#102-e v022

[2] R2-2008122 report from R16 eMIMO-CLI-PRN-RACS - R17 NTN-REDCAP breakout session

[3] R2-2008191 Summary of offline 109 - Reduced capability signalling framework Intel

[4] R2-2006751 Reduced capability signalling framework Intel Corporation

[5] R2-2006911 Framework and Principles for Reduced Capability Ericsson

[6] R2-2006605 Defining and constraining UEs with reduced capabilities Qualcomm Inc

[7] R2-2007110 RedCap UE characterization and access restriction Apple

[8] R2-2007400 Discussion on how to define reduced capability devices LG Electronics UK

[9] R2-2007011 On definition and constraint of reduced capabilities CATT