**3GPP TSG RAN WG1 #102-e R1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

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

**Title: Summary on [102-e-NR-RedCap-04]**

**Agenda Item:** **8.6.4**

**Document for:** **Discussion and Decision**

1. **Introduction**

This contribution summarizes the following email discussion/approval in AI 8.6.4 regarding the framework and principles for RedCap.

[102-e-NR-RedCap-04] Email discussiona/approval – Shinya (DCM)

* By 8/26

1. **Discussion**
   1. **Definition of a limited set of one or more device types**

## How to define UE type for RedCap

In [2][7][9][15][16][20][21][22], how to define UE type for RedCap is discussed. While some of them assume existing UE feature/capability framework as the baseline, there are two alternatives as pointed out by [15] as follows.

* Alt.1: stick to the NR framework which would be just added NR features with the NR capability reporting framework
* Alt.2: define a field for reporting the device type and the corresponding set of capability parameters with predefined values (per device type) (similar to LTE ue-Category)

So, it would be good to discuss at first whether existing UE feature/capability framework can be assumed as the baseline (i.e. Alt.1) to define UE type for RedCap.

### **FL proposal#1:**

* **Existing UE feature/capability framework is the baseline to define the UE type for RedCap**

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| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | N | We think we should first discuss and conclude how many redcap device types will be introduce, before selecting between alt 1 and alt 2. Furthermore, we think RAN2 should be involved for such discussion and decision. |
| Panasonic | Y | Our interpretation of existing UE feature/capability means the signaling is based on the functionality and not device type. We propose to modify "Existing UE feature/capability signaling framework". To stick to existing UE feature/capability signaling framework has following merit.  - technical discussion can be progressed independently from type discussion, which also need to take into account market requirement.  - Interoperability testing (IOT) aspect like "mandatory with signaling" is possible depending on the deployment status. |
| FUTUREWEI | Y | Using the existing framework is the default. It would be a big change to add UE categories to NR. Note that the existing framework now includes the ability to designate things as ‘basic feature groups’. |
| Qualcomm | Y | A minimal set of UE features can be specified for RedCap device, which constitutes the baseline or basic UE feature group that differentiates RedCap UE from legacy (NR Rel-15/16) UE. |
| DOCOMO | Y | Agree with FUTUREWEI and Qualcomm. We can reuse the basic FG concept to define the UE type for RedCap. |
| ZTE | Y | UE type based on existing UE feature/capability framework can be defined for RedCap. The UE features/capabilities that RedCap UEs support are a subset of the features/capabilities that normal NR UEs support. |
| OPPO | Y | Agree with FUTUREWEI and Qualcomm. |
| Samsung |  | Existing UE feature/capability framework can be reused. But this can be decided by RAN 2. And it is needed to identify the features that a RedCap UE would support before discussing the frame work. |
| Xiaomi |  | It is hard to say Yes or No before the UE type definition is clear to us. |
| Novamint |  | Agree with Vivo and Samsung. We need to define first how many redcap types will be introduced and RAN2 should lead this topic. |
| LG | N | For the two alternatives, we need to discuss which way is better in terms of signaling overhead, specification impact, and so on. And also an important criteria should be the future proofing for further introduction of more device types. As we don’t have a clear answer on it yet, it is hard to agree on the FL proposal #1 at this moment. We don’t see a clear majority as well from the summary below.  From our perspective, Alt.2 is preferred in terms of signaling overhead and the readability of the set of capability parameters specific to a RedCap device type. But it is also our view that regardless of RAN1 preference, the final decision seems to be up to RAN2 especially for the signaling structure and the details. |
| InterDigital | Y | Existing UE feature/capability framework can be reused. |
| Fraunhofer | Y | Agree to having the existing UE feature/capability framework as a baseline. |
| CMCC | Y | Defining UE type RedCap based on existing UE feature/capability framework can be supported, which the Explicit UE type can realize early access control from network. |
| Nokia, NSB | Y | We should use the existing framework to define a minimum set of features for RedCap UE |
| Ericsson | Y | Details of the capability framework to be discussed in RAN2. |
| Huawei, HiSilicon | N | In our view, it is kind-of a mix of both alternatives, i.e. one type for RedCap UE (for FR1) is defined by a minimum (mandatory) capability set, on top of which additional optional UE features can be reported with existing capability framework. Additionally, this type can be reported during the initial access, while optional UE features are assumed to be reported after initial access. |
| SONY | N | We have a similar view to vivo. We think there needs to be some conclusion on the number of Redcap device types that will be introduced before selecting between Alt 1 and Alt 2. |
| Convida | Y |  |
| Lenovo, Motorola Mobility | Y | The existing UE feature/capability framework can be used to define only limited number of UE type(s) for RedCap, details to be discussed in RAN2. |

In addition, some contributions further discuss whether/what additional mechanisms on top of existing UE feature/capability framework are necessary.

### **FL proposal#2:**

* **Study whether any additional mechanisms on top of existing UE feature/capability framework are necessary to define the UE type for RedCap**

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| **Company** | **Agree (Y/N)** | **Comments** |
| vivo |  | Fine to study, but would be good to list the potential areas for study.  And we have the same comment as in the previous question. |
| Panasonic | Y | Some mechanisms to prevent market fragmentation would be useful. It would be some combinations/groups of UE feature indications. Our current view is that it is scenario/use case specific type. On the other hand, commonality among use cases is not excluded. |
| FUTUREWEI | Y | Agree with Panasonic, this is similar to the RAN discussion that led to basic feature groups. One of the RAN options (which is still open to be used as needed) is to define some group outside of the table. This may be needed for RedCap in the sense that there may be feature groups from other releases (which are not in the same table) that may be recommended for RedCap UEs. |
| Qualcomm | Y | RAN2 should be involved for such discussion and decision. |
| DOCOMO | Y | As commented to FL proposal#1, we think basic FG concept can be reused to define the UE type for RedCap. For example, if we have low and high UE types for RedCap, we can define basic FGs as   * FG#A-a, #B-a for low UE type * FG#A-a, #A-b, #B-a, #B-b for high UE type   Regarding the mandatory FGs (with/without capability signalling) in Rel.15, e.g., FG2-3 (PDSCH MIMO layers), which will not be supported by RedCap UE, adding note in the corresponding RedCap FG that “UE supporting this FG does not necessarily support FG2-3” would be enough. Detail can be further discussed when FGs for RedCap are defined. |
| ZTE | Y | During initial access, minimal set of UE features/capabilities are assumed for the RedCap UEs. After initial access, existing UE feature/capability framework is used to signal UE capability for RedCap UEs. |
| OPPO | Y | Scenario/use case specific basic feature groups can be defined for different RedCap UE type. |
| Samsung |  | It is OK to study, but the study should be led by RAN 2. And it is needed to first identify the features that a RedCap UE would support before study the framework. |
| Xiaomi |  | Same as P#1 |
| Novamint |  | Agree with Samsung. This should be led by RAN2 |
| LG | Y | We agree with CATT in that the signaling framework should support multiple UE types for future-proofing. |
| InterDigital | Y | We agree that FG concept can be used for this purpose. |
| Fraunhofer | Y | Agree with Qualcomm. Nevertheless we support having feature groups for different RedCap UE types. Given the very diverse use cases in the SID, different types will probably be necessary anyways.  Table 1 in contribution [16] is a good starting point. |
| CMCC | Y | Either UE feature group or RedCap UE type can be studied. |
| Nokia, NSB | Y | OK to study additional mechanism that can be used e.g. to define different types of RedCap UE, for early identification of RedCap during initial access, etc. |
| Ericsson | Y | Additional mechanisms could include early identification of RedCap UEs and restriction or bundling of certain features. This study should be led by RAN2. |
| Huawei, HiSilicon | N | FL proposal #1 should be studied firstly and this proposal can be discussed based on the progress of FL proposal #1. |
| SONY | Y | We are OK to study additional mechanisms, but it would be good to list potential areas for study. |
| Convida | Y | Additional mechanisms such as early identification of RedCap UEs may be studied, but this study should be led by RAN2. |
| Lenovo, Motorola Motility | Y | Not that clear about the additional mechanisms to define UE type, but early identification of UE type could be studied. |

Note: Interested companies are also encouraged to provide their views on what additional mechanisms are necessary.

*Companies view in contributions*

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| <FUTUREWEI [2]>  **Observation: The RedCap “framework” may include both the traditional feature/feature group description, and additional “recommended” features from across Rel-15 to Rel-17.**  <CATT [7]>  **Proposal 1: The reduced capabilities can base on existing UE capability signalling framework.**  **Proposal 2: Further discuss the required changes to the existing UE capabilities, or need for new components based on output of the SI.**  **Proposal 4: The signalling framework supports multiple UE types for future-proof in terms of extendibility.**  **Proposal 5: A UE type is linked to a UE capability level, i.e., a given set of reduced UE capabilities.**  **Proposal 6: Further discuss whether a UE capability level can be linked to more than one UE types.**  <Intel [9]>  Proposal 3:   * *Device type is used as an additional mechanism on top of explicitly signalling all the UE capabilities as in legacy NR. The number of device types should be minimised and introduced only where essential to control UE accesses and industry classification.*   + *This could be realized based on the minimum requirements on the channel BW, which is a common and most significant property that is expected to be different from regular NR UEs.*   < LG Electronics [15]>  The following two high level alternatives are suggested for further discussion.   * Alt. 1 stick to the NR framework which would be just added NR features with the NR capability reporting framework * Alt. 2 define a field for reporting the device type and the corresponding set of capability parameters with predefined values (per device type) (similar to LTE *ue-Category*)   ***Proposal 2: For framework to support reduced capability NR devices, further discuss between the two alternatives above.***  <Panasonic [16]>  **Proposal 9: UE features are expressed by functionality-based structure which is similar to Rel.15/16. The scenario specific requirement is specified independently from the UE feature signalling.**  **Table 1. UE features for each use case**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Feature list based on UE type | Industrial Sensors | | Video Surveillance | | Wearables | | | General | Safety related sensors | Economic video | High-end video | Low-end | High-end | | Maximum number of (DL) MIMO layers | 1 | 1 | 1 | 1 | 1 | 2 for FR1;  1 for FR2. | | Tx antenna | 1 | 1 | 1 | 1 | 1 | 1 | | Rx antenna | 2 | 2 | 2 | 2 | 2 | 2 | | Maximum modulation order | FFS | FFS | FFS | FFS | QPSK | 64QAM for FR1 DL;  QPSK or 16QAM for FR2 DL. | | Bandwidth | FFS | FFS | FFS | FFS | FFS | FFS | | UE processing time | [More relaxed N1/N2] | FFS | [More relaxed N1/N2] | FFS | [More relaxed N1/N2] | FFS | | HD-FDD | FFS | FFS | FFS | FFS | FFS | FFS | | Others, e.g. | HARQ is baseline | Repetition is baseline | Consider BWP framework and CG  Mobility: stationary or low | | Consider power saving features | | | Consider:  DCI format 0\_2/1\_2  Small data enhancement including 2-step RACH  Power saving features | |   <CMCC [20]>  One way is no explicit UE categories. Considering that a maximum UE bandwidth of 20MHz is supported for FR1, the RedCap NR devices can support all the current CORESET#0 configuration in section 13 of TS38.213. Since default scheduling and feedback timing and low modulation order is used during initial access, all the RedCap UEs can realize initial access. Then with capability report, gNB can provide UE specific configuration corresponding to it capability to realize low UE cost, low complexity, etc.  Another way is to define explicit UE categories. By this way gNB can distinguish UE capability in an early phase, such as by separate PRACH configurations, and also the network can facilitate early access control for different UE categories. Considering that both 50MHz and 100MHz maximum UE bandwidth will be studied for FR2, the network can configure separate initial BWPs for RedCap devices with different capabilities. For example, for high-capability devices, the 100MHz initial BWP of eMBB/URLLC can be reused for initial access. For devices with lower capabilities, they can access through a initial BWP with bandwidth of 50 MHz.  **Proposal 7.** **Whether to define explicit UE categories needs further study.**  <OPPO [21]>  For the specification of device type, RedCap UEs can be defined through UE capability signaling, or based on UE feature sets. Either way can be considered further. In our view, two RedCap UE types are acceptable, with one type for low-end RedCap UEs and the other for high-end RedCap UEs. It is not desirable to have too many RedCap UEs types, which will bring specification complexity and market fragmentation.  < InterDigital [22]>  In NR, a UE is characterized by a set of capabilities and UE categories are not used to differentiate between the UEs. Given the diverse set of requirements and use cases for RedCap UEs, it may not be feasible to extend the NR framework to include capabilities for RedCap UEs. To define the RedCap UEs, two options may be considered:   * Reuse the NR framework by introducing restrictions on the number of potential capability combinations. * Define a new framework with new device types   ***Proposal 1: Discuss whether to introduce new device types for RedCap UEs.*** |

## Number of UE types

In [1][3][4][8][10][15][17][18][19][21], how many UE types are defined for RedCap is discussed. For FR1, some companies prefer single UE type while others prefer two UE types. For FR2, some companies prefer single UE type while others think more discussion is needed. While definition of each UE type would need more discussion, following would be considered for the progress.

### **FL proposal#3:**

* **Study at most two UE types for each FR for RedCap**
  + **FFS the definition of each UE type**

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| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | Y |  |
| Panasonic | FFS | At first FL proposal#1 should be concluded. Then the meaning of UE types should be concluded. |
| FUTUREWEI | N | The proposal is too open and may promote market fragmentation, as well as standardization difficulties. A better proposal would be to strive for a single UE type. |
| Qualcomm | N | A single RedCap device type is preferred for each FR. |
| DOCOMO | N | Agree with FUTUREWEI and Qualcomm that we should strive for a single UE type for each FR to avoid market fragmentation.  Regarding the definition of the single UE type, at least a set of FGs which is necessary in SA operation (e.g., initial access, RLM/RRM) should be included if these FGs are not the same as current FGs similar to NR-U. |
| ZTE | Y | Single UE type for each FR can be considered for initial access. For FR1, 20 MHz UE bandwidth is assumed for RedCap UEs for initial access. Another UE Bandwidth larger than 20 MHz can be considered after initial access for FR1. For FR2, 100 MHz UE bandwidth is assumed for RedCap UEs for initial access. |
| OPPO | Y | The differentiation of high-end and low-end RedCap UE types is preferred. |
| Samsung |  | Although more discussion is needed, the number of UE types should be limited.  The proposal should be clarified that this is for FR 1 and FR2 respectively, i.e., two types for each frequency range. OK to assume at most two for now as working assumption and confirmed when the complexity reduction techniques are clearer. |
| Xiaomi | Y | 20M bandwidth and 1Rx/1Tx should be the one of them, as the base type. |
| Novamint | FFS/Y | Agree with Panasonic.  Currently, we would favor a differentiation between low end and high-end RedCap UE types but this needs to be discussed more |
| LG | Y | Based on the condition that the framework is compatible with future introduction of more device types along with the NR deployment being more popular, we can accept the FL proposal. And, we would like further clarification by adding “in Rel-17” at the end. |
| InterDigital | Y | We can limit the maximum number of UE types to 2 for each FR. |
| Fraunhofer | Y | Agree with Oppo to limit the number of device types to two. Still we need to agree what exactly defines a UE type for RedCap. For FR2 we propose to only have one type here. |
| CMCC | Y | We are open to define one or two UE type(s). |
| Nokia, NSB | Y | We think at most two UE types for FR1 would be sufficient. For FR2, only one UE type is sufficient. |
| Ericsson | Y | We would like to strive for as few UE types as possible. Preferably the same UE type can handle all the targeted use cases adequately. However, we expect there may be some band-dependent differences, not only between FR1 and FR2, but possibly also between low-band and mid-band UEs and/or FDD and TDD UEs. |
| Huawei, HiSilicon | N | Not sure if all companies have the same definition of UE type in mind, which seems open in FL proposal#1. To avoid market fragmentation, one RedCap UE type per FR is sufficient. |
| SONY | Y | We should minimize the number of UE types. This proposal seems to be linked to FL proposal#1 since it is unclear how we would arrive at a “UE type” when there are many optional features within a feature group. |
| Convida | Y | A maximum of 2 device types for each FR should be sufficient. |
| Lenovo, Motorola Mobility | Y | Prefer at most 2 UE types for FR1, and 1 for FR2. |

Note: Companies are also encouraged to provide their views on the definition of each UE type.

*Companies view in contributions*

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| <Ericsson [1]>   1. The RedCap study item conclusions recommend defining one RedCap UE type in FR1. The definition of the RedCap FR1 UE type includes a minimum set of UE capabilities supporting operation in FR1 adequately for targeted use cases, balancing the considerations on achievable cost reduction benefits and economy of scale. 2. The RedCap study item conclusions recommend defining one RedCap UE type in FR2. The definition of the RedCap FR2 UE type includes a minimum set of UE capabilities supporting operation in FR2 adequately for targeted use cases, balancing the considerations on achievable cost reduction benefits and economy of scale.   <vivo, Guangdong Genius [3]>  **Proposal 1: introduce two RedCap UE categories/ types, one is to cover the low-end use cases, the other is to cover the high-end use cases:**   * **Type 1 RedCap UEs for industrial sensors, economic video, low-end wearable use cases** * **Type 2 RedCap UEs for high-end wearable and high-end video Surveillance use cases** * **Table 2: two device types/ categories for RedCap**  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Device type/ category** | **Use cases** | **Peak data rate** | **Rx/Tx antenna** | **Bandwidth** | | Type 1 RedCap  (corresponding to LTE Cat 1bis) | Industrial sensors, economic video, low-end wearable | 10Mbps in DL  5Mbps in UL | 1Rx/1Tx | 20MHz | | Type 2 RedCap  (corresponding to LTE 4) | High-end video Surveillance, high-end wearable | 150Mbps in DL  50Mbps in UL | 1Rx, 2Rx, 1Tx | 20MHz and above |   <ZTE [4]>  ***Proposal 1: UE type for reduced capability NR devices can be defined based on a baseline maximum UE bandwidth for initial access.***  ***Proposal 2: For reduced capability NR devices,***   * ***For FR1, 20 MHz maximum UE bandwidth is considered for initial access. In Connected Mode, 20 MHz and another maximum UE bandwidth larger than 20 MHz can be considered.*** * ***For FR2, single UE category with 100 MHz UE bandwidth is considered for initial access and Connected Mode.***   < Lenovo, Motorola Mobility [8]>  ***Proposal 1: Define one or two device types with 20MHz maximum UE bandwidth for FR1.***  ***Proposal 2: Define one device type with 50MHz maximum UE bandwidth for FR2.***  < Xiaomi [10]>  **Proposal 1: More than one Redcap device types providing different peak data rate should be supported to adapt different use cases**  **Proposal 2 : 1Rx/1Tx and 20MHz bandwidth should be assumed as the basic RedCap device type**  **Proposal 3: Further study the following two options for the high-end device type**   * **Option 1: 40MHz and 1 Rx** * **Option 2: 20MHz and 2Rx**   < LG Electronics [15]>  ***Proposal 1: Discuss whether to support the three target use cases of the reduced capability NR devices with a single device type or multiple device types.***  <Huawei, HiSilicon [17]>  **Observation 1: From network point of view, multiple UE types do not help the network constrain RedCap UEs with different use cases, or with different traffic for the same use case in real systems.**  **Observation 2: It is not desirable to define RedCap UE type for specific use cases from the perspective of chipset economy, and the business success of RedCap.**  **Proposal 1: As Principle-1, consider to define one RedCap UE type without differentiation among specific use cases for Rel-17.**  **Proposal 2: As Principle-2, consider to define the RedCap UE type based on single type of chipset with upper bound requirements in baseband, allowing adaptive device forms to be supported by network.**  < Sequans [18]>  **Observation 1: RAN1 needs to discuss more on the need of single or multiple RedCap UE types.**  <Qualcomm [19]>  ***Proposal 1: Study how and how many RedCap device types are defined.***   * ***In case a single RedCap device type is defined, the device type should cover a wide range of use cases and requirements.*** * ***In case two RedCap device types are defined, consider one type for low-end RedCap devices and the other for high-end RedCap devices.***   <OPPO [21]>  One issue to be considered during SI is the definition of a limited set of one or more device types. In our view, the RedCap device type can be defined according to the requirement of use cases.  For the requirements of power saving, low cost/complexity and device size with high priority, most of the following potential UE complexity reduction features should include:   * Reduced number of UE RX/TX antennas * UE Bandwidth reduction * Half-Duplex-FDD * Relaxed UE processing time * Relaxed UE processing capability * Reduced PDCCH monitoring * Extended DRX for RRC Inactive and/or Idle * RRM relaxation for stationary devices * Coverage recovery   The devices with these requirements can be defined as one type. Industrial wireless sensors, low-end video and wearables are the examples of this device type. This can be considered as low-end RedCap device type. It is near to the LPWA (i.e. LTE-M/NB-IOT) like device type.  For the requirements not sensitive to device size, power consumption and cost, the following potential UE complexity reduction features are not critical:   * Reduced number of UE RX/TX antennas * UE Bandwidth reduction * Relaxed UE processing time * Relaxed UE processing capability * Coverage recovery   The devices with these requirements can be defined as one type. High-end video and wearables are the examples of this device type. This can be considered as high-end RedCap device type. This type of UEs can achieve higher data rate and low latency. It is near to the URLCC and eMBB like device type.  ***Proposal 1: Two RedCap UEs types with different key requirements are defined for RedCap in Rel-17.*** |

* 1. **Constrain RedCap devices to be used only for the intended use cases**

In [1][7][9], how to constrain RedCap devices to be used only for the intended use cases is discussed. [1] assumes it is studied in RAN2 and not discussed further in RAN1, [7] assumes it is not necessary to explicitly define the restriction, and [9] assumes it is supported by existing capability signalling framework or device types. As it might be too early to conclude no more discussion in RAN1 at this stage, following is considered for the discussion.

### **FL proposal#4:**

* **Studying how to constrain RedCap devices to be used only for the intended use cases is deprioritized in RAN1**

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| **Company** | **Agree (Y/N)** | **Comments** |
| Vivo | Y | This should be discussed in RAN2. |
| Panasonic | Y | This should be deprioritized in RAN1 as it is more related to signalling. |
| FUTUREWEI | Y |  |
| Qualcomm | Y | This should be discussed in RAN2 first.  Network should validate a UE’s RedCap indication against UE’s subscription to ensure it does not receive services unintended for RedCap UEs. 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. |
| DOCOMO | Y |  |
| Spreadtrum | Y | This should be discussed in RAN2. |
| ZTE | Y | This can be handled in RAN2. |
| OPPO | Y | This should be discussed in RAN2. |
| Samsung |  | This discussion should happen in RAN2. |
| Xiaomi | Y | However, if the constrain mechanism has impact on RAN1 specification, then we can come back to in RAN1. |
| Novamint | Y | RAN 2 |
| LG | Y | Companies seem to think constraining RedCap devices to be used only for the intended use cases is   * a RAN2 issue, * not necessary, or * already supported.   Also given that this topic is RAN2-led according to the SID, if there is no suggestions otherwise, we can leave this for RAN2 discussion, and we think there is no need to make any formal agreement/conclusion on this. |
| InterDigital | Y |  |
| Fraunhofer | Y | This should be deprioritized. |
| CMCC | Y |  |
| Nokia, NSB | Y |  |
| Ericsson | Y |  |
| Huawei, HiSilicon | Y | Such study is done in RAN2 and RAN2 can inform potential RAN1 impact if any. |
| SONY | Y | This should be discussed in RAN2. |
| Convida | Y |  |
| Lenovo, Motorola Mobility | Y | This should be discussed in RAN2 |

*Companies view in contributions*

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| <Ericsson [1]>   1. Features for constraining RedCap devices to be used only for the intended use cases are assumed to be studied in RAN2 and not discussed further in RAN1.   <CATT [7]>  **Observation: There seems no need to explicitly define restriction of reduced capabilities to certain use cases.**  < Intel [9]>  Observation 1:   * *Ensuring that a particular device type is only used for the intended use case is possible using existing capability signalling framework or device types. The actual check can be left to the network.*   Proposal 1:   * *The SI objective of “checking device is used only as intended” can be met using existing capabilities or a device type.* |

* 1. **Others**

## General principles

In [4], general principles for RedCap are discussed considering limited TU allocated for the reduced capability SI and the motivation of complexity reduction as follows:

• Only single carrier is considered for reduced capability. Not support carrier aggregation

• For initial access, reuse legacy solutions as much as possible

• Minimum standardization impact

It is FL’s understanding that the latter two are the common understanding in RedCap and no agreement is necessary. For the first one, it is true that whether CA can be considered for RedCap is unclear because SID only states “Note4: This SI should focus on SA mode and single connectivity”. So, following is considered for the discussion.

### **FL proposal#5:**

* **Only single carrier is considered for reduced capability. Not support carrier aggregation**

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| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | Partially Y | We can assume single carrier during the study and work item phase. But eventually in the UE feature discussion, we think there is no need for specification to explicitly prevent a redcap UE to support carrier aggregation. Therefore we propose to revise the proposal as:  **Single carrier is prioritized for reduced capability UEs**  In addition, we would like to prioritize the basic BWP feature for RedCap UEs, i.e. Rel-15 feature 6-1. |
| Panasonic | Y | As a study item, not to support carrier aggregation is sufficient.  At work item phase, it is not required to have explicit restriction from the specification perspective. |
| FUTUREWEI | Partially Y | The reference already has operation in a single band at a time. The wording will need to be modified, as CA will not be prevented as Vivo says. Perhaps something like “CA is not studied”, without the first part. |
| Qualcomm | Y | We don’t think CA should be supported by RedCap UE. |
| DOCOMO | N | Although we don’t see the benefit to introduce CA in RedCap so far, it should not be precluded as CA is optional feature. Proposal from vivo and FUTUREWEI would be enough for the SI. |
| Spreadtrum | Partially Y | CA can be further studied. |
| ZTE | Y | Carrier aggregation increases the transceiver bandwidth and increase the cost and complexity of the UE. |
| OPPO | Partially Y | Single carrier could be baseline. CA is FFS. |
| Samsung |  | Considering only single carrier in the SI is fine, however there is no need to agree that carrier aggregation is not supported. |
| Xiaomi | Y | We do not see the need for RedCap to support CA |
| Novamint | Y | CA should not be considered at this stage – potentially for next release |
| LG | Y | We agree with the FL’s introductory remarks, that is, the second and third bullets are not needed. Only the first one is clear enough and helps make a progress. |
| InterDigital | Y |  |
| Fraunhofer | Partially Y | Agree with Samsung that CA should not be studied but there is no reason to not support it.. |
| CMCC | Partially Y | CA need further study. |
| Nokia, NSB | Y | For study on complexity reduction techniques, it is sufficient to consider only single carrier |
| Ericsson | Y | We agree that CA should not be mandatory for RedCap UEs. Whether RedCap UEs can support CA as an optional feature or not can be left for the WI phase. |
| Huawei, HiSilicon | Y only with modification | Please replace “single carrier” with “single cell” given the proposal intention to preclude CA. CA is not supported for RedCap UE. As discussed in our contribution (R1-2005269), CA increases the total UE bandwidth and requires more receiving RF chains, which is opposite to RedCap design target. |
| SONY | Y | At least in the study item phase we do not need to study CA for Redcap UEs. |
| Convida | Y |  |
| Lenovo, Motorola Mobility | Y | At least no need to be included in the UE type definition. |

*Companies view in contributions*

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| <ZTE [4]>  ***Proposal 3: For reduced capability NR devices, the following principles should be considered for utilizing the potential UE complexity reduction features:***   * ***Only single carrier is considered for reduced capability. Not support carrier aggregation*** * ***For initial access, reuse legacy solutions as much as possible*** * ***Minimum standardization impact*** |

## Coexistence with legacy UE

In [3][13][17][19][20][22], coexistence with legacy UE is discussed including:

* Initial access (SSB/CORESET#0/PRACH/SIB1/initial BWP/Paging): [3], [13], [17], [19], [20], [22]
* Beam-based operation in FR2: [19]

Based on the above, it would be worth discussing whether coexistence issue with legacy UE in terms of at least initial access should be studied or not. It is FL’s understanding that any coexistence issues related to AI 8.6.1 - 8.6.3 should be discussed in the corresponding AI.

### **FL proposal#6:**

* **Study coexistence issue with legacy UE in terms of initial access**
  + **Note: other aspects are not precluded**

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| **Company** | **Agree (Y/N)** | **Comments** |
| vivo | Y |  |
| Panasonic | Y | How to ensure coexistence is always necessary work in 3gpp regardless what is written in study item description. |
| FUTUREWEI | N | We may not need an explicit proposal or discussion here so far, let us see how the coex aspects for the complexity reduction techniques proceed. |
| Qualcomm | Y | Link budget evaluations for RedCap UE have indicated DL coverage loss for msg2 and msg4 in initial access, wherein the coverage loss is resulted from reduced number of RX antennas [19].  To improve the resource utilization efficiency of the network as well as the energy efficiency of UE, it is important to study the co-existence issue for legacy UE and RedCap UE during the course of initial access. |
| DOCOMO | N | We think this aspect can be discussed in AI 8.6.1, i.e., whether current initial access scheme can be reused for RedCap or not should be determined based on the UE complexity reduction features. |
| Spreadtrum | Y | Share the same view with Panasonic. |
| ZTE | Y | The coexistence issue is related to the discussion in 8.6.1 and 8.6.3 |
| OPPO | Y | Agree with Panasonic’s view. |
| Samsung |  | Coexistence is also discussed in email discussion 02. It is needed to merge the two discussions. We agree that coexistence issues in initial issues needs to be addressed. |
| Xiaomi | Y |  |
| Novamint | Y |  |
| LG | N | Most of the proposals below seem to be the main topics for the Others sub-agenda where we can have discussions for the details taking into account the coexistence issues. We don’t think we need any agreement/conclusion in this sub-agenda. |
| InterDigital | Y |  |
| Fraunhofer | Y | Agree with Panasonic |
| CMCC | Y | Coexistence issue should be studied to prevent performance degradation of legacy UEs. When the network needs to offload the RedCap UEs from initial access phase or enhanced design is used for the initial access channels, such study is necessary. |
| Nokia, NSB | Y |  |
| Ericsson | N | The listed coexistence issues seem more related to 8.6.1 and 8.6.3 than to 8.6.4. |
| Huawei, HiSilicon | Y | The coexistence issue with legacy UE in terms of initial access should be studied, while taking into account of the impact on legacy performance, the economies of scale for RedCap UE and the network configuration flexibility. |
| SONY | Y | Coexistence issues are going to be studied under AI 8.6.1 in any case, so we don’t see the need to explicitly consider coexistence under AI 8.6.4. |
| Convida | Y |  |
| Lenovo, Motorola Mobility | Y | The coexistence issue with legacy UEs during initial access is relevant and shall be studied. |

*Companies view in contributions*

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| <vivo, Guangdong Genius [3]>  Regarding to the design framework, we think it is important to first discuss the initial access mechanism for RedCap UEs since depending on the discussion outcome, e.g. the same or different initial access scheme with the legacy UEs, the design framework, solutions and specification efforts would be different.  **Proposal 2: For cell search, study following options for RedCap UEs and legacy UEs:**   * **Option 1: Shared SSB, separate CORESET#0** * **Option 2: separate SSB, separate CORESET#0**   **Proposal 3: For random access, study following options for RedCap UEs and legacy UEs:**   * **Option 1: shared PRACH resource** * **Option 2: separate PRACH resource**   <CMCC [13]>  **Proposal 1: The network should be able to control access of reduced capability NR devices, to avoid performance degradation and realize traffic offloading.**  **Proposal 2: The design for reduced capability NR devices should be able to realize flexible resource sharing and can easy capacity extension.**  **Proposal 3: BWP framework can be used for reduced capability NR devices, to provide flexible capacity extension ability and offload traffic, to realize early network control.**  **Proposal 4: Further study is needed for different options to realize BWP framework.**   * **Option 1: More than one cell defining SSBs can be transmitted in one cell, and PBCHs can indicate different initial BWPs,** * **Option 2: one common cell defining SSB is transmitted, but different CORESET#0 for reduced capability devices to receive scheduling information of SIB1,** * **Option 3: common SSB and common CORESET#0 as eMBB devices are received, but SIB1 information is transmitted in different BWPs.**   <CMCC [20]>  Based on the above analysis, different initial BWPs can be used to serve the RedCap devices, and the following advantages can be achieved,   * By configuring different initial BWPs, RedCap NR devices with different maximum UE bandwidth can be served in the same cell; * Different transmission schemes can be used on different initial BWPs for UE with different capabilities. For example, when determining the MCS of broadcasted system information, a BWP serving 1Rx RedCap devices needs a higher MCS than BWP serving 2Rx. For low capability UEs that only support a relaxed UE processing time compared to capability #1, the PUSCH scheduling before RRC configuration may need a separate default PUSCH TDRA table. When different initial BWPs can be used to serve the RedCap UEs, the transmission schemes can be more suited to the corresponding UE capabilities. * The network can facilitate access control on specific BWP, such as by rejecting access of certain types of terminals to ensure service quality of the other type of terminals. * By flexible configuring the number of initial BWPs for RedCap devices, the network can realize traffic offload according to the number of UEs served and the required service quality.   **Proposal 8.** **BWP framework can be used to serve RedCap NR devices with different capabilities, to offload traffic and facilitate access control.**  <Huawei, HiSilicon [17]>  **Proposal 3: Whether or not the SIB1 can be shared between RedCap UE and normal UE can be decided by the network***.*  **Proposal 4: Support dedicated UL initial BWP/RACH resources for RedCap UE**   * **Whether to share UL initial BWP/RACH resources between RedCap UE and normal UE can be configured by the network.**   **Proposal 5: Whether to share paging resources between RedCap UE and normal UE can be configured by the network taking into account the false alarm probability, the paging capacity, and the resource overhead.**  <Qualcomm [19]>  ***Proposal 2: Study the co-existence of RedCap devices with NR Rel-15/16 UE and minimize the L1 impacts by:***   * ***re-using the waveform, numerologies, channel coding, physical signals and control/data channel structure of NR Rel-15*** * ***re-using the UE capability transfer mechanism of NR Rel-15 after RRC connection*** * ***re-using the PSS/SSS sequences and PBCH/SIB1 design of NR Rel-15***   ***Proposal 6: For FR2, study a separate cell search and initial access design for RedCap devices to balance early discovery of RedCap systems (UE power and acquisition time), resource overhead, and network flexibility.***   * ***Separation may be from SSB, CORESET0, RMSI, or RACH*** * ***Study techniques to reduce the resource duplications due to such separation***   ***Proposal 7: For FR2, study more efficient ways to:***   * ***reduce beam overloading and interference for stationary or slow moving UEs;*** * ***reduce beam direction blockage to accommodate other UEs in times when beams are preconfigured for RedCap UEs.***   ***Proposal 8: For FR2, study ways to reduce the UL and DL resources utilizations for RedCap devices by:***   * ***utilizing a leaner RedCap design*** * ***re-using as much as possible resources used by the non-RedCap UE***   ***Proposal 9: For FR2, study additional ways to mitigate PRACH collisions and resource overloading to improve UE power efficiency and latency.***  < InterDigital [22]>  The BW of the CORESET0 may be larger than the maximum BW supported by a RedCap UE. For example, when 60 kHz subcarrier spacing and 96 RBs are used, the CORESET0 may span a BW of 69.12 MHz, potentially exceeding the maximum BW a RedCap UE can support. To overcome this problem, one approach may be to use a separate region for CORESET0 for RedCap UEs. This can achieved by without impacting the existing UEs by indication a new set of Type0 PDCCH CSS using the configuration information in the MIB.  ***Proposal 2: Discuss whether to introduce a new initial access mechanism for RedCap UEs.*** |

## Use case vs capability

In [16], necessary UE feature/capability and/or enhancement to support a use case is discussed. It is FL’s understanding that such discussion should be done in the corresponding AI 8.6.1 - 8.6.3. If there is no corresponding AI, it can be discussed here. As only one company showed view on this aspect, companies are encouraged to provide their views on this aspect.

### **Question#1:**

* **Which UE feature/capability is necessary to support a use case other than those discussed in other AIs, if any?**
* **What enhancement is necessary to support a use case other than those discussed in other AIs, if any?**

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| **Company** | **Comments** |
| vivo | It seems a UE feature discussion which should happen towards the end of the work item. |
| Panasonic | These can be discussed later when determining what feature should be supported in what type of UEs. If type is not scenario specific, it is not required to be discussed. |
| FUTUREWEI | This could be later, if needed. As mentioned earlier, there may be recommendations in the end that RedCap UEs support certain Rel-15 and -16 FGs. |
| Qualcomm | We can defer the discussion about this topic till the end of the SI/WI, after progress is made for the baseline UE features of RedCap devices. |
| DODOMO | This can be discussed after the features in AI 8.6.1 – 8.6.3 are discussed well. |
| Spreadtrum | Share the same view with vivo. We may not achieve consistence in SI stage. |
| ZTE | This can be discussed later. |
| OPPO | Share the same view with Qualcomm. |
| Samsung | It is important to study the different features first. This discussion can be done at a later stage. |
| Novamint | To be discussed at a later stage when features to be supported per type of UE are identified |
| LG | This discussion can be deferred to a later stage. For the moment, focusing on the basic features/capabilities seems more efficient. |
| InterDigital | We agree that this discussion can be deferred. |
| Fraunhofer | Agree with Qualcomm |
| CMCC | Agree to discuss this issue later. |
| Nokia, NSB | This should be discussed later |
| Ericsson | We agree with the FL view that this discussion can take place in 8.6.1 – 8.6.3. |
| Huawei, HiSilicon | In our view, the minimum (mandatory) capabilities for RedCap UE should be studied firstly. This question can be discussed in this AI with low priority but not now. |
| SONY | This can be discussed later, if needed. |
| Convida | This can be discussed later. |
| Lenovo, Motorola Mobility | To be discussed later |

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| <Panasonic [16]>  **Proposal 1: For industrial wireless sensor scenarios, two major new types of UEs can be identified for clearer UE categorization, which are general wireless sensors and safety related sensors. To achieve service availability of 99.99%,**   * **For general wireless sensors, HARQ is baseline.** * **For safety related sensors, repetition is baseline.** * **For both types, low MCS level including reduced modulation order is baseline.**   **Proposal 2: For PDCCH reliability and flexibility in industry wireless sensor scenarios, DCI format 0\_2/1\_2 can be considered.**  **Proposal 3: For industry wireless sensor scenario, small data enhancement including 2-step RACH could be considered for reduced capability UEs. Also, the bandwidth reduction should be considered to fit the traffic packet size. Whether to reuse the legacy initial access channels should also be studied.**  **Proposal 4: Power saving related enhancement should be considered for industry wireless sensor scenario.**  **Proposal 5: For video surveillance scenario, a number of parameter sets of packet size and arrival periodicity can be used to characterize the UL periodic traffic model:**   * **Reference economic video: If the packet arrival periodicity is T ms, the packet size (potential size of MAC PDU or TBS) could be [2,4] Kbits \* T.** * **High-end video: Similar with the above case, if the packet arrival periodicity is T ms, the packet size could be around [7.5, 25] Kbits \* T.**   **Proposal 6: For video surveillance scenario, BWP framework and CG should be considered to support the service.**  **Proposal 7: For video surveillance scenario, the assumed UE mobility level could be low or even stationary. Thus, RRM relaxation could be considered.**  **Proposal 8: Power saving enhancement should be considered for wearable use case. To investigate how the battery life of the device can be extended to 1-2 weeks, traffic model and battery life calculation methodology should be agreed.** |

## Other comments

Comments that do not fit in any of the previous sections of this document but related to AI 8.6.4 can be provided in this section.

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| **Company** | **Comments** |
| Samsung | In general, we’d like to wait for RAN 2’s guidance first since this item is led by RAN 2. |
| Novamint | Agree with Samsung |
| Ericsson | Agree with Samsung |
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* 1. **Topics to be discussed in other AIs**

Potential UE complexity reduction features

In [11][12][18], aspect related to potential UE complexity reduction features is discussed, but this should be discussed in AI 8.6.1.

Reduced PDCCH monitoring

In [11], aspect related to reduced PDCCH monitoring is discussed, but this should be discussed in AI 8.6.2.

Coverage recovery and capacity impact

In [11][12], aspect related to coverage recovery and capacity impact is discussed, but this should be discussed in AI 8.6.3.

Access control of RedCap UE

In [3][5][6][8][9][14][19], aspect related to access control of RedCap UE is discussed, but this should be discussed in AI 8.6.5.

Identification of RedCap UE

In [6][8][9][10][14][19], aspect related to identification of RedCap UE is discussed, but this should be discussed in AI 8.6.5.

**Reference**

1. [R1-2005237](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005237.zip) Framework and principles for RedCap Ericsson
2. [R1-2005279](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005279.zip) Framework for RedCap UEs FUTUREWEI
3. [R1-2005386](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005386.zip) Framework and Principles for Reduced Capability vivo, Guangdong Genius
4. [R1-2005477](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005477.zip) Views on Framework and Principles for Reduced Capability ZTE
5. [R1-2005528](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005528.zip) Framework and Principles for Reduced Capability Nokia, Nokia Shanghai Bell
6. [R1-2005640](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005640.zip) On the framework for RedCap UEs MediaTek Inc.
7. [R1-2005717](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005717.zip) Framework and principles for reduced capability NR devices CATT
8. [R1-2005832](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005832.zip) On Framework and Principles for RedCap Lenovo, Motorola Mobility
9. [R1-2005883](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005883.zip) Introducing NR RedCap UEs: Overall framework Intel Corporation
10. [R1-2005971](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005971.zip) Discussion on framework and principles for reduced capability device Beijing Xiaomi Software Tech
11. [R1-2006039](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006039.zip) Consideration on reduced UE capability OPPO
12. [R1-2006155](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006155.zip) Framework and Principles for Reduced Capability Samsung
13. [R1-2006220](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006220.zip) Discussion on principles and framework of reduced capability NR CMCC
14. [R1-2006287](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006287.zip) Discussion on Framework and Principles for Reduced Capability Spreadtrum Communications
15. [R1-2006309](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006309.zip) Consideration on the framework to support reduced capability NR devices LG Electronics
16. [R1-2006388](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006388.zip) Discussion on Framework and Principles for Reduced Capability Panasonic
17. [R1-2006406](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006406.zip) Framework and principles for reduced capability devices Huawei, HiSilicon
18. [R1-2006686](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006686.zip) Framework and principles for RedCap UE Sequans Communications
19. [R1-2006814](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006814.zip) Standardization Framework and Design Principles for RedCap Devices Qualcomm Incorporated
20. [R1-2006217](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006217.zip) Discussion on potential UE complexity reduction features CMCC (from AI 8.6.1)
21. [R1-2006040](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006040.zip) Other considerations for reduced UE capability OPPO (from AI 8.6.5)
22. [R1-2006687](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006687.zip) Access restriction for reduced capability NR devices InterDigital, Inc. (from AI 8.6.5)