**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. |
| Intel | Y | The existing NR UE capability reporting framework should be maximally reused. Definition of device types can be based on a very limited particular set of features/requirements, and remaining indication of UE capability reporting should reuse the current framework. |
| China Telecom | N | Share the same view with VIVO and Samsung. |
| Sharp | Y | The existing UE feature/capability framework can be reused. Combination of FG sets can be studied to correspond to several RedCap UE types with reduced capabilities. |
| CATT | Y | Existing UE feature/capability framework should be reused as baseline. |
| MediaTek | Y | Existing UE feature/capability framework should be reused as baseline.  In our view, a given type of RedCap UE is defined by a minimum mandatory capability set, which similar to R15. RedCap UE can use existing reporting framework to report optional features (again, similar to what is done in R15).  In other words, the only difference between RedCap UE and full-capable UE is the mandatory set of features. |
| Moderator | **Observations:**   * 19 companies (Panasonic, FUTUREWEI, Qualcomm, DOCOMO, ZTE, OPPO, InterDigital, Fraunhofer, CMCC, Nokia, NSB, Ericsson, Convida, Lenovo, Motorola Mobility, Intel, Sharp, CATT, MediaTek) support FL proposal#1 in principle   + 7 companies (FUTUREWEI, Qualcomm, DOCOMO, OPPO, Nokia, NSB, MediaTek) think RedCap UE type is defined by minimum set of UE features (e.g., basic feature groups) * 1 companies (Huawei, HiSilicon) think 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 as a starting point. * 1 company (LG) prefer to define RedCap UE type similar to UE category in LTE * 8 companies (vivo, Samsung, Novamint, LG, Ericsson, Lenovo, Motorola Mobility, China Telecom) think RAN2 should lead this topic * 4 companies (vivo, Novamint, SONY, China Telecom) think RAN1 should first conclude how many RedCap UE types will be introduced * 1 company (Xiaomi) think UE type definition should be discussed first   Based on the observations above, it seems difficult (or not appropriate) to decide how to define UE type for RedCap in this RAN1 meeting. FL proposes to postpone the discussion on this topic in this RAN1 meeting and see RAN2 progress. | |

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. |
| Intel | Y | However, RAN1 should defer to RAN2 on this. |
| China Telecom |  | we have the same comment as in the previous question. |
| Sharp | Y | Early identification of RedCap UE type could be studied. |
| CATT | Y | Additional mechanism should be studied for e.g. access control, UE identification etc. |
| MediaTek | Y | Fine to study. |
| Moderator | **Observations:**   * 21 companies (Panasonic, FUTUREWEI, Qualcomm, DOCOMO, ZTE, OPPO, LG, InterDigital, Fraunhofer, CMCC, Nokia, NSB, Ericsson, SONY, Convida, Lenovo, Motorola Mobility, Intel, Sharp, CATT, MediaTek) support FL proposal#2 in principle   + 2 companies (vivo, SONY) think it is good to list the potential areas for study   + 2 companies (Panasonic, FUTUREWEI) think some mechanisms to prevent market fragmentation can be studied   + 4 companies (Panasonic, FUTUREWEI, OPPO, Fraunhofer) think scenario/use case specific RedCap UE type can be studied   + 1 company (LG) thinks the framework should support multiple UE types for future-proofing   + 7 companies (Nokia, NSB, Ericsson, Convida, Lenovo, Motorola Mobility, Sharp) think additional mechanism for early identification of RedCap UE can be studied   + 1 company (Ericsson) thinks additional mechanism for restriction or bundling of certain features can be studied   + 1 company (CATT) thinks additional mechanism for access control and UE identification should be studied * 9 companies (vivo, Qualcomm, Samsung, Novamint, Fraunhofer, Ericsson, Convida, China Telecom, Intel) think RAN2 should lead this topic or RAN1 should defer to RAN2 on this topic * 2 companies (Samsung, Xiaomi) think UE type definition should be discussed first * 2 companies (Huawei, HiSilicon) think FL proposal #1 should be studied first   Based on the observations above, it seems difficult (or not appropriate) to decide whether to study additional mechanisms on top of existing UE feature/capability framework in this RAN1 meeting. FL proposes to postpone the discussion on this topic in this RAN1 meeting and see RAN2 progress. | |

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. |
| Intel | N | A single RedCap device type is preferred per FR. Remaining distinction and dependencies based on bands, etc. may be communicated via the NR capability reporting framework. |
| China Telecom | Y | Prefer 2 device types |
| Sharp | Y | UE types should be minimized. It may not be necessary for all Redcap UEs to support all the FGs for the high functionality e.g. to meet the 150M peak date rate. This could be done by capability signaling as well. |
| CATT | Y | Up to 2 UE types per FR should be sufficient. |
| MediaTek | N | We agree with FUTUREWEI, Qualcomm, DOCOMO and others that we should strive for a single UE type for each FR to avoid market fragmentation. |
| Moderator | **Observations:**   * 19 companies (vivo, OPPO, Xiaomi, Novamint, LG, InterDigital, Fraunhofer, CMCC, Nokia, NSB, Ericsson, SONY, Convida, Lenovo, Motorola Mobility, China Telecom, Sharp, CATT) support FL proposal#2 in principle   + 13 companies (FUTUREWEI, Qualcomm, DOCOMO, ZTE, Fraunhofer (for FR2), Nokia, NSB (for FR2), Huawei, HiSilicon, Lenovo, Motorola Mobility (for FR2), Intel, MediaTek) prefer a single RedCap UE type     - 20 MHz UE BW for FR1 and 100 MHz UE BW for FR2 for initial access: ZTE   + 4 companies (OPPO, Novamint, Fraunhofer (for FR1), China Telecom) prefer two RedCap UE types (not counting the companies answering at most two)     - High-end and low-end: OPPO, Novamint   + 1 company (LG) suggests to clarify “in Rel-17”   + 1 company (Ericsson) thinks RedCap UE type may have band-dependent differences * 4 companies (Panasonic, Huawei, HiSilicon, SONY) think FL proposal #1 should be concluded first * 1 companies (Samsung) is OK as working assumption and it is confirmed when the complexity reduction techniques are clearer   As some companies think FL proposal #1 should be concluded first while some others think FL proposal #3 should be concluded first, we should find a way to progress. Unlike FL proposals #1 and 2, no companies think RAN2 should lead this topic. Besides, no companies think more than two RedCap UE types are necessary. So, FL updates the proposal as follows | |

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

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

* **Study following two alternatives in Rel.17 RedCap SI, to be down-selected later**
  + **Alt.1: Single UE type for each FR**
  + **Alt.2: Two UE types for each FR**
  + **FFS the definition of each UE type**

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| **Company** | **Agree (Y/N)** | **Comments** |
| Huawei, HiSilicon | N | According to the observation provided by Moderator, majority views (13 out of 19 companies) are to support a single RedCap UE type per FR. One RedCap UE type per FR is sufficient for initial access since it is adequate for network to differentiate RedCap UE from legacy UEs. Optional RedCap UE features can be assumed to be reported after initial access. Additionally as replied previously, one type is essential to avoid market fragmentation. Therefore, single UE type for each FR is suggested. |
| Panasonic | N | If the number of types are required to be studied before the conclusion of UE feature/capability framework and the meaning of type, we view the number of UE types are just a kind of image of types. Considering the amount of flexibility and the amount of work, we share the view from Nokia/NSB, i..e. two UE types for FR1 and one UE type for FR2. It can be a compromise of two alternatives. |
| Nokia, NSB | N | Similar view as Panasonic. It would be better for the proposal to explicitly separate the alternatives for FR1 and FR2 as we prefer 2 for FR1 and 1 for FR2. |
| MediaTek | N | Single UE type for each FR is sufficient to cover the considered use-cases in general, and it should be the baseline approach in the SI/WI.  From cost perspective, it is essential to not have more than one device type (for each FR), as the segmentation of the market will lead to an increase in the device’s cost. So, having single UE type goes with the main objective of the SI to introduce low cost NR devices.  From power saving perspective, this is mainly dominated by the configuration rather than the UE capability. |
| Fraunhofer |  | Agree with Panasonic. FR1[2] and FR2[1] could be a good compromise. |
| FUTUREWEI | N | The proposal says we could have two of something but no idea how the something is even defined. Is it one or two “UE types” to support both 1RX and 2RX 20MHz UEs? Is it a another UE type to have 100MHZ (no BW reduction) but to have antenna reduction? If we use the current framework with a single basic feature and some dependent basic and optional features on top of it, is that one UE type? I expect that some are thinking that we will introduce UE categories in NR, and the categories will correspond to the UE types and therefore will take a hard line till that earlier proposal is put to rest. We do not agree to UE categories for NR, or to encouraging fragmentation with a proposal listing two UE types in it. What we should have is a “motherhood and apple pie” statement of striving for a single UE type (regardless of whether that type is ever really visible as a “type”). |
| Intel | N | Given that we potentially have divergent ideas about what constitutes a “UE type” (or the core functionality in defining UE types), it may be better if we could discuss that a bit, or, may need to defer to RAN2, before agreeing on how many types.  In our view, UE type definition can be useful primarily to distinguish RedCap UEs from regular NR UEs, and relevant to access control and UE identification. Certainly there could be multiple variants of RedCap devices considering the diverse use cases. However, the NR capability reporting framework provides full functionality to realize such, especially if it can help realize less fragmentation in core capabilities. |
| ZTE |  | This issue is related to the definition of RedCap UE type. It should be discussed after we have clear definition of RedCap UE type. We show similar view as Intel that UE type definition can be useful primarily to distinguish RedCap UEs from regular NR UEs. For example, RedCap UE type can be defined as a set of capability (maximum UE bandwidth, number of Tx/Rx antenna, etc) for initial access.  The number of UE type issue is also under discussion in RAN2. But the exact definition of RedCap UE type is assumed to be discussed in RAN1. |
| Samsung | N | Since there may be a case that one FR define single UE type, the other FR define two UE types, therefore, we suggest to go back to original proposal:   * **Study at most two UE types for each FR for RedCap**   + **FFS the definition of each UE type**   Besides, a clarification question, do we preclude the case that UE report a redcap capability (group), and report some optional features (including larger BW, more Rx, etc) for Alt 1? |
| Spreadtrum | - | In our view, cost reduction is more crucial than market fragmentation. In industry vertical, the market fragmentation is always present and cost is more sensitive. So, Two UE types in FR1 is our preference.  On the other hand, we do not think “UE type” used here means “category”. UE type(s) only impact access control and UE identification, as mentioned by Intel. How many “UE type(s)” are just impact the details of access control and UE identification. We are not defining “categories”. |
| Xiaomi | - | Before we say yes or no, we need to have the same understanding on the definition of UE type. In our opinion, the UE type can be defined based on the provided data rate. At least in FR1, High-end devices provide high data rate and low-end devices provide low data rate. |
| LG |  | It is basically a trade-off b/w cost/complexity reduction and market fragmentation. Traditionally market fragmentation many be more important at the beginning, but the cost/complexity reduction/optimization becomes more and more important as the market grows. That’s why we think the framework should be compatible with the future introduction of more device types.  For the number of device types, “at most two” is okay for us as a compromise, but don’t think we have to set the hard limit on the number of device types to ‘1’ even for FR2.  For the discussion on whether it should be the NR capability or the UE category, it can be left for RAN2 discussion or at least deferred to a later stage. |
| Ericsson |  | The term “UE type” hasn’t been clearly defined, which makes this discussion a bit difficult. In our view, a UE type can be defined as a set of reduced capabilities. For each operation band, we think that it will be enough with a single UE type for addressing the targeted use cases. 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, so per this UE type definition we may need 1-2 UE types for FR1 and 1 UE type for FR2. Note that when the UE accesses a cell, the UE type (the set of reduced capabilities) can be immediately deduced from the band. For a given band, there will only be a single UE type, which should help avoid market fragmentation and simplify the signaling solutions. |
| Sequans |  | Before going into the discussion about alternatives, we need to understand first what is meant by “UE type”, as also already mentioned above by others. Our concern is that UE type as in the LTE category definition may need to be service related to avoid market confusion. Although we understand the simplicity of definition by set of features we may need to consider if it will be efficient to link UE types with too technical aspects – won’t this probably lead to increased complexity for RAN4 to come up with performance requirements and conformance test specifications by RAN5? On the other hand, if we are only talking about access control and identification here, it should be perfectly clarified. Maybe RAN2 is more appropriate to lead discussion on this. |
| DOCOMO | Y | Our understanding of the proposal is that we will study two alternatives considering the definition of each UE type. If we find single UE type is enough for RedCap, we will take Alt. 1, but if we find there is critical issue to define only one RedCap UE type, we have no choice but take Alt. 2. In that sense, we can support the proposal. |
| Lenovo, Motorola Mobility |  | Better to discuss the alternatives for FR1 and FR2 separately. And we feel that it might be good to firstly settle down the discussion on BW, Rx number (MIMO layer), modulation order before we discuss how many UE types to be defined. |
| Sharp |  | It would be difficult to consider the number of UE type, given we do not have a clear picture on the specific definition of UE type and the usage of the UE type to be used for. We think the number of UE types would be dependent on the definition and usage of the UE type. If the UE type is primarily intended for differentiating the legacy NR UEs, one type is sufficient. If the UE type is primarily intended for differentiating the RedCap UEs with different reduced capabilities (e.g. low-end device and high-end device with different sets of reduced capabilities in FR1), up to two types should be considered. |
| Moderator | **Observations:**   * Almost no companies can accept the updated FL proposal#3 due to the following reasons:   + Prefer single UE type for each FR (Alt.1):     - Huawei, HiSilicon, MediaTek, FUTUREWEI   + Prefer two UE types for FR1 and single UE type for FR2:     - Panasonic, Nokia, NSB, Fraunhofer, Spreadtrum (FR1)   + Prefer original proposal “Study at most two UE types for each FR for RedCap”     - Samsung, LG   + Better to discuss the definition of UE types first     - Intel, ZTE, Xiaomi, Ericsson, Sequans, Lenovo, Motorola Mobility, Sharp   + Better to defer to RAN2 first     - Intel, Sequans * 1 company (Ericsson) points out there low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1 may be necessary * 1 company (ZTE) suggests the exact definition of RedCap UE type is discussed in RAN1   Based on the observations above, maybe it would be acceptable to go back to original proposal with some modifications as below:   * **Study at most two UE types striving** **for a single UE type for each FR for RedCap in Rel.17**   + **FFS: low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1**   Please note that similar discussion is held in “[109][REDCAP] Reduced capability signalling framework” in RAN2 as below:  **Potential conclusion 3:** **The number of device types should be minimised and introduced only where essential to control UE accesses and industry classification, e,g, differentiate them from legacy R15/16 UEs, ( number of Tx/Rx antennas, maximum supportable BW, etc. ). The exact composition of this set can be discussed by RAN1.**  While the discussion is not concluded yet, it may be worth discussing the exact composition (i.e., what defines RedCap UE type) in RAN1. Based on the comments so far, the followings can be considered as possible compositions to define RedCap UE type(s):   * Function-specific:   + minimum set of UE features (e.g., basic feature groups)   + minimum (mandatory) capability set + additional optional UE features * Scenario/use case-specific:   + High-end, low-end   + IWSN (general, safety related sensors), Video surveillance (economic video, high-end video), Wearables (low-end, high-end)   As a consequence, FL further updates the proposal as follows | |

### **Further updated FL proposal#3:**

* **Study at most two UE types striving** **for a single UE type for each FR for RedCap in Rel.17**
  + **FFS: low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1**
  + **FFS the definition of each UE type with the followings as the stating point**
    - **Alt.1: Function-specific**
    - **Alt.2: Scenario/use case-specific**

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| **Company** | **Comments** |
| vivo | We have concern on the updated proposal #3, about whether one or two UE types should be defined for each FR, there is clearlydifferent views among companies, several companies prefer single type, similar amount of companies prefer two types. Therefore we do not think “striving for a single UE type” should be included in the proposal. We would be fine with the following update.   * **Study at most two UE types ~~striving for a single UE type~~for each FR for RedCap in Rel.17**   + **FFS: low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1**   + **FFS the definition of each UE type with the followings as the stating point**     - **Alt.1: Function-specific**     - **Alt.2: Scenario/use case-specific** |
| Moderator | Regarding the point you raised, I would like to hear companies view who support two UE types. Do you think striving for a single UE type or minimizing the number of UE types is not necessary? If you think it's necessary, I don't think we have to remove that part. If you don't think it's necessary, can you compromise to keep that part as it does not mandate us to study only one UE type, but just shows the direction. You can obviously study up to two UE types. If that part is removed, maybe some companies object to the proposal as they don't prefer studying up to two UE types without any condition. |
| vivo | Thanks for your question. We do agree we should keep in mind that the number of UE types can be minimized, however, that does not mean we should have an target for single UE type.  Economic of scale is important aspect to consider we agree, but the power efficiency of the modem is also important. Our observation is that there is difference in power consumption between LTE cat 0 and cat 4 modem, this is not only for connected mode, but also for idle mode.  It is good to hear more companies view, but from our perspective, studying at most two UE types is already one step minimize the number of UE types, without good justification on the cost and power efficiency, we are not convinced that a single UE type can address different use cases. |
| Apple | We also have concern on updated proposal 3. Before we have solid understanding what components is included in UE type definition, it is difficult to judge how many types we need. We should first agree the components i.e. how to define UE type and then determine how many we need for Redcap devices. |
| Xiaomi | For the updated proposal#3, We share the same view with vivo.  We agree with minimizing the number of UE types is necessary, so we are OK with restricting the number of UE types to 2 at most. But we don’t think we should go further and strive for only one UE type.  In our opinion, the requirement of use case identified for Redcap is quite diverse. Defining only one UE type is not cost efficient and power efficient. So for each FR, we prefer that define two UE types and different UE type provides different data rate. So we suggest to follow vivo’s modification.          And we also have one question on the following bullet. We can’t understand Alt.1 well, can you clarify a bit more about what is “function-specific”.   * + **FFS the definition of each UE type with the followings as the stating point**     - **Alt.1: Function-specific**     - **Alt.2: Scenario/use case-specific** |
| Moderator | Regarding the question from Qin, As I wrote in v046, some companies think that RedCap UE type can be defined by a minimum set of UE features (e.g., basic feature groups) or a minimum (mandatory) capability set + additional optional UE features. Here I call this way as "Function-specific" as UE feature discussion. |
| LG | LG also has a problem with adding the “**striving for a single UE type**” in the proposal.  We tend to think supporting the “diverse” target use cases for RedCap by a single device type can’t be very efficient in terms of cost/complexity, power consumption, etc.  We should make a decision that strikes a balance among the market fragmentation, cost/complexity optimization, specification efforts, etc., but hard limiting the number of device types to one at this stage is far from the balance.  From our perspective, at most two device types are already a compromise, so we are not okay with any further restrictions beyond the two.  As some company commented below, the **Alt.1: Function-specific**in the FFS is not clear, while the Alt.2 is clear as it is.  Our preference is to either further clarify the Alt.1 or remove the whole FFS, and to try agree on the following main bullet.   * **Study at most two UE types striving for a single UE type for each FR for RedCap in Rel.17** |
| OPPO | OPPO have problem to formulate the new proposal #3. We should not conclude target to a single UE type, without justifying the different use case and scenarios included so far. It seems this is not a minority view and should not be overlooked.    The lack of UE types for different capability will prevent further commercial success for NR. |
| ZTE | Regarding low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1, what is the intention to differentiate them? |
| Samsung | I think for now, we can stay with at most two UE types. How many UE types/how to define UE type(s) can be discussed later when cost reduction features are more clear.  In addition, we don’t fully understand why to add the second FFS and what is meaning or different between Alt 1 and Alt 2, although you provided some examples in v46.  We don’t think the definitions had been fully discussed and can be easily agreed by the group. Therefore, we suggest to delete the second FFS as below:   * **Study at most two UE types ~~striving for a single UE type~~for each FR for RedCap in Rel.17**   + **FFS: low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1**   + **~~FFS the definition of each UE type with the followings as the stating point~~**     - **~~Alt.1: Function-specific~~**     - **~~Alt.2: Scenario/use case-specific~~** |
| Moderator | Regarding the comment from Jay on Alt.1: Function-specific, my understanding is that Alt.1 defines UE type as a set of UE features as we adopted for NR-U basic feature groups. For example, there are a number of FGs defined for RedCap (e.g., #1: 20MHz BW, #2: 1Rx, #2': 2Rx, #3: Less BD/CCE limits, #4: Coverage recovery for PDSCH, etc), and some of them (e.g., #1,2) are defined as the basic FGs for RedCap, the set of basic FGs defines RedCap UE type. The basic FGs may be the same or different among use cases. But maybe different companies have different understanding. It would be very appreciated if the proponents of Alt.1 could further clarify the intention.    Regarding the question from Huiying, this was suggested by Ericsson. @Ericsson, could you clarify the intention?    So far we have received the concern on "striving for a single UE type" in the main bullet from a number of companies.  Can we live with the modification from Samsung, especially for companies who support single UE type, to make progress? |
| Ericsson | Regarding “low-band/mid-band differentiation and/or FDD/TDD differentiation in FR1”, our intension is to keep the possibility open for allowing different numbers of UE antennas in different FR1 bands. This is based on the consideration of balancing the tradeoff between UE cost reduction and coverage loss. For example, for the operation bands that require 4 Rx, perhaps RedCap UEs can support 2 Rx, and for the operation bands that require 2 Rx, perhaps RedCap UEs can support 1 Rx. Perhaps, low-band/mid-band differentiation or FDD/TDD differentiation does not fully capture the bands differentiation for 4Rx and 2 Rx. So, perhaps it is better to say “2Rx/4Rx band differentiation”.    For FR2, there is no need to have band differentiation in terms of number of Rx, so one UE type is sufficient.    We are fine with Samsung’s proposal, but it would be good to further limit the number of UE types in FR2 to 1. |
| LG | According to your understanding on the Alt.1 of the device type definition, there doesn’t seem to be much difference b/w Alt.1 and Alt.2 from our point of view in that both of them should be defined by a set of feature or feature groups any way.  It would be also good to know if other companies have different understanding on Alt.2 during this discussion :--)  My understanding on the Alt.2 is the set of feature groups defining the device type is defined per use case or scenario, while for Alt.1, the relationship between the set of feature groups and the use case doesn’t have to be explicitly specified somewhere in the spec?  If it is removed, then we have no problem with the proposal at this time, but it would still be good to hear from other companies on a little bit of details of what they think on the device type definition before trying to get aligned with each other.    Regarding the last comment from Eric, the number of Rx doesn’t necessarily define the device type.  It’s just one aspect of defining the device type.  So, from our perspective, for the same reason mentioned in the previous e-mail, limiting the number of device types to one should not be applied to FR2 as well. |
| FUTUREWEI | The issue with any of these proposals is that we have no common understanding on what a UE type is, so it does not make sense to talk about how many of this unknown thing there will be. I think that everyone should agree that we anyway have the existing framework of the UE feature table and the concept of basic features. This is not an "alternative", it is the default. We would need a very strong reason to throw this away and do something like introduce UE categories in NR, or some other new definition that has spec impact. Perhaps not all proponents of fragmentation see UE category and UE type as the same, but it is clear that many do. (e.g., see Vivo's table with the heading "Device type/ category" )    We mentioned striving for a single UE type. This means we have the type that is used for access/identification and do not introduce other concepts that are not needed on top of our existing capabilities framework. Intel has made a similar comment. Many of the properties that people are thinking may be associated with some UE type will be capabilities or basic feature definitions that are known depending on the band of operation. Ericsson also pointed out in one response. So it not even clear that in the spec there will be a "FR2 Redcap UE", there may just be a Redcap UE.    PS Eric, we agree with your observations on that we may not want to support 1RX in bands that now require 4RX, but are not sure this will be reflected in the UE type discussion. If we only agree to support 2RX in those bands then no special handling is needed perhaps. However, people may have different views as to whether 1rx and 2rx would be different types (if supported). |
| Intel | However, for similar reasons, as explained by FutureWei and others below, we cannot agree to Further updated FL proposal#3, and especially so, if “**striving for a single UE type**” is removed. In fact, this could even be seen as counter to RAN2’s decision below:  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;   For band-dependent requirements, while we understand the motivation behind Ericsson’s proposal and are fine with the basic intent, we do not think this would require us to define separate UE types – one per subset of FR1 bands. We have similar understanding as FTW, that to realize different requirements as function of bands, we do not need to introduce multiple UE types. The result can be that we have two different RedCap UEs, but from “device type” consideration, there may only be a single “type” of RedCap UE – further distinction can be realized naturally by the existing NR capability reporting framework. The same logic applies to the option of defining “a number of UE types per FR” in the main bullet.    Please note that we are not saying that there cannot be more than one RedCap UE type either, but just highlighting as to why the proposal to define up to two types per FR, etc. is pre-mature, given what we know now about the RedCap UE design options. We think a lot of these details would get clearer at a later stage, likely during the WI phase, especially those motivated by use-cases/etc.  Thus, at present, the UE type consideration should focus on the need for UE identification for access control purposes, and for this, we think a single “device type” should be the starting point. |
| Ericsson | Regarding the number of UE “types”, I think it’s very good if the SI can answer the question whether a single UE can adequately address all targeted use case requirements and other relevant requirements. If the answer is no, then it would be good if the SI can describe what sort of different UEs that will be needed. If the answer on the other hand is yes, then perhaps it is quite clear that there are benefits from economies-of-scale point of view. If it is difficult to conclude on whether the answer is yes or no in this meeting, I think it might be ok to conclude in the next meeting instead. |
| Apple | Referring to the RAN2 agreement cited by Debdeep, e.g. bullet 1, it seems that the device type, at least from RAN2 perspective, is mainly used to facilitate network to  identify UEs and apply access restriction properly. We are not so sure this common understanding on the function of UE types. That’s the reason I emphasized in previous email that it is important to establish common understanding on the function of UE types, the components of this (also pointed by RAN2 agreement i.e. number of Tx/Rx antennas, maximum supported BW in 3rd bullet), then we can discuss and draw conclusion how many UE types we need, considering both associated function, economical scale and cost reduction objectives.  It is unclear for us why we need to draw this conclusion as it is clearly premature. We even can determine this at the end of this SI or even at the start of WI, e.g. based on number of Rx Redcap needs to support and bandwidth numbers needs to support.  Long in short, the need to draw this conclusion seems unclear and even cause certain unnecessary restriction for other designs. |
| Huawei/HiSilicon | We also feel the phrase “striving for a single UE type” is very important in the main bullet for proposal 3, and don’t feel it is appropriate to introduce two UE types before we have some sort of consensus on its definition. In our understanding, one UE type is a minimum set of mandatory UE capabilities which may inherit some of basic features of Rel-15 (featured as mandatory without signaling, e.g. PUSCH mapping type A/B) but also may include some reduced capability from those basic features of Rel-15 (e.g. 20MHz bandwidth v.s. 100Mhz). It would be better for us to identify the potential elements in the set before we can discuss whether the second UE type is necessary, because we should really avoid fragmentation.           Regarding the second subbullet, we don’t feel Alt.2 is clear because use cases are hard to be well-defined in RAN stage-3 specifications and incorporated into the existing UE capabilities framework that has just been confirmed as a baseline by RAN2. We suggest to remove Alt.2. |
| Qualcomm | Regarding “Further updated FL proposal#3”, we can accept different proposals for FR1 and FR2. In FR1, we support “striving for a single UE type.”  For FR2, we are fine with “study at most two UE types.” |
| Moderator | Given that companies view on the number of RedCap UE types is still divergent, and RAN2 made following agreement which Debdeep kindly shared with us, let's follow the RAN2 agreement highlighted by yellow right now, and use the rest of time for this email discussion to discuss the possible components of the UE type to get common understanding in this group as suggested by some companies.  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; |

### **Question:**

* **Which components should be included in the definition of the RedCap UE type (e.g. number of Tx/Rx antennas, maximum supportable BW, etc.)?**

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| **Company** | **Comment** |
| Apple | We believe the Redcap type should be defined with two rules in mind, 1) differentiating the normal device and RedCap UEs 2) avoid unnecessary restriction on devices to access network. Following this, maximum supported bandwidth is sufficiently enough. Supported MIMO layers can be reported as part of UE capability after RRC connection setup as in legacy system. |
| Spreadtrum | We think the cost reduction is more important than the market fragmentation in industrial vertical. To address the cost reduction, both the number of RX antennas and the maximum data BW should be considered in the definition of the RedCap UE type. These two aspects may both impact the access procedure in RAN1/RAN2. For ease of discussion of impact of access procedures in RAN1/RAN2, it is better to define two UE types with a considerable cost gap. By the way, it should be clarified that we are not defining“category”. |
| DOCOMO | We think a set of features which is necessary for initial access should be included if these features are not the same as current features due to reduced capability. Such features may include maximum supported BW, # of Rx, and potential coverage recovery techniques for the channels in initial access. After the initial access, UE can report its capability by existing framework, and such capability does not necessary to be included in the definition of the RedCap UE type. |
| ZTE | We think the intention to define RedCap UE type is for initial access. The definition of RedCap UE type includes capability of maximum UE bandwidth and number of Tx/Rx antennas during initial access. After initial access, other UE capabilities can be signaled by legacy capability signaling. |
| SONY | It is generally difficult to talk about what is included in the definition of a RedCap UE type given that we don’t have a common understanding of what “Redcap UE type” is (echoing Brian/FTW’s comment).    However, there seems to be a need to define a Redcap UE type for initial access reasons. The number of Tx / Rx antennas probably needs to be associated with the UE type. Whether UE bandwidth needs to be associated with UE type for initial access purposes depends on what conclusions about UE bandwidth are reached in 8.6.1. There may also be other reasons to define a UE as being of a certain “type”, such controlling access to certain use cases (IWS, wearables, smartphones) and these issues could be discussed in RAN2 or 8.6.5 (or here??). |
| Intel | As such, we can anticipate different RedCap UEs designed for different use-cases and different capabilities to best tradeoff between cost, complexity, power consumption, and performance.    With these objectives, we can see that, from perspective of device implementation, the flexibility in realizing differentiated support of various UE features can be fully realized using the NR capability reporting framework. If there is a benefit to the industry in further defining “types”, e.g., based on use-cases, is not clear at this point, but at the same time, not expected to be clear either unless we know much more about the RedCap UE – so, an appropriate time for such discussion would be latter part of the WI phase. However, for such an objective to provide industry guidance, such classification need not be communicated to the NW until the regular capability reporting, and hence, need not be considered at this point in discussing UE type characterization from RAN1 perspective.    In addition to the above, due to the limited capabilities of RedCap UEs compared to non-RedCap NR UEs, the NW also needs to know of the existence of these UEs when such UEs may try to get connected to the NW, in order to either: (1) prevent them from accessing the NW; or (2) configuring and scheduling of common control and random access-related channels appropriately for RedCap UEs.    For access control purposes (at least to differentiate from non-RedCap UEs), it is sufficient to identify based on a single distinctive property – and, as pointed out by Apple, the max UE BW is the perfect candidate for such.  Number of Tx/Rx branches could possibly be relevant, if we decide to support multiple options for the UE for # of Tx/Rx branches for a given band; otherwise, not necessary. One more potential property could be based on form-factor constraints for FR1, if we decide to support consideration of reduced antenna efficiency due to small form-factor constraints. Thus, once we have the UE max BW-based characterization, the remaining two (if applicable) would be the only ones with potential to impact initial access performance. However, the need to define UE types also considering number of Tx/Rx branches and/or form-factor constraints may not be clear until we get to the normative phase.    We acknowledge the comment from SONY that, in theory, there could even be access control based on use-cases, however that definitely entirely falls in RAN2 domain. Considering the RAN2 discussion on this so far, it seems unlikely they would make further progress on any such motivations until we get to the normative phase.    Thus to summarize, we think at least UE max BW should be included; with others (e.g., num Tx/Rx branches, form-factor constraints) can be FFS. |
| Huawei, HiSilicon | We think the factors defining one UE type can be categorized into two categories,   * Impact on initial access: Maximum UE channel bandwidth, number of Rx antenna. * No impact on initial access: Maximum DL&UL MCS.     We have a different view from Spreadtrum. Economies of scale is very important and provides significant cost reduction, therefore, we should avoid market fragmentation.    In Rel-15 capability framework, there is some UE capabilities without capability signaling. We don’t feel they will be signaled by REDCAP UEs, although they may not impact on the definition of UE type. |
| Ericsson | Considering the RAN2 agreement below, there is no urgency for RAN1 to discuss the definition of the RedCap UE type. We suggest coming back to this discussion after we have a better view on which cost reduction and power saving techniques are promising for RedCap. For now, we suggest focusing on identifying cost reduction and power saving techniques that may have impact on initial access.     |  | | --- | | 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; | |
| FUTUREWEI | RAN2 has clearly stated that:   * they need to know whether the UE is "Redcap UE" or not * they have not agreed to the need of a device type * device types, if agreed, should be minimized to avoid market fragmentation, and introduced only if ESSENTIAL to distinguish from non-RedCap UEs. Device types are NOT considered for creating different RedCap UEs for different RedCap use cases and distinguishing them from each other (this includes small form factor use cases). * the existing UE capabilities framework is baseline * whether and how a device type is used is postponed to the normative phase   So, while we can collect some views on e.g. antennas, BW, etc it is not very urgent.    Our *current*view is that bandwidth *may*be related, but it is not sure yet what we might recommend from the study with regards to antennas. If there turns out to be massive amounts of compensation required for some configurations, these will have big network impacts and should likely not be recommended. For some configurations, however, if we focus on bottleneck channels and reasonable deployments, it could turn out that not so much compensation is needed. If not much compensation is needed for all recommended combination of bandwidth/antenna, then there should be no need for device types. It will be sufficient to just know the UE is a "RedCap UE", some aspects will be known from the band the UE is accessing (e.g., FR1 vs FR2), and the full capabilities will become known later as usual. |
| Moderator | Regarding the components UE type, based on the comments so far, a number of companies think it's not urgent, so we can postpone the discussion in this meeting. |
| LG | From RAN1’s perspective, the “potential” components defining the RedCap device types could consist of the UE supported bandwidth, number of MIMO layers (or number of Rx antennas) and the supported modulation order (if reduction in the modulation order is supported). The RedCap device types can be defined by (a) certain combination(s) of them. As those components are related to the supported max data rate, they can be easily mapped to certain use cases (or use case specific requirements) later on.  We could also think of the case where not all components are used to define the RedCap device types if benefits of some of the components are not clear and therefore not supported, which may become clearer perhaps at the end of the SI.  So, the best thing we can do to make a progress in this meeting is to list up the components for further study or just defer this discussion to a later stage. |
| vivo | We think at least BW and #Rx should be included in the UE type definition.  We tend to agree with Ericsson that we should focus on the what complexity reduction features are supported and defer this UE type discussion to a later stage, e.g. in the WI phase. |
| Xiaomi | We share similar view with LG.  UE types can be defined based on the provided data rate. The maximum UE bandwidth, number of MIMO layer and the supported modulation order which impact the data rate can be considered as potential components to define the Redcap device types.  As commented by some companies, since the complexity reduction features are not fixed yet, we can come back to this issue at later stage |
| Spreadtrum | As response to Huawei, we do not notice the two types of devices with large cost difference have negative impact to the economies of scale. In LTE, cat 1bis and cat 4 UEs are both make the market prosperous by fulfilling different cost demand.  On the other hand, if companies dislike “type” or “category”, “low-end mode” and “high-end mode” can be used only for purpose of discussion. We do not expect the new restrictive terminologies in the RAN1 spec either. |
| Qualcomm | We think the UE type definition can be based on the baseline/basic UE features of RedCap devices, which can include the UE BW and Tx/Rx antenna configuration. Considering companies have different views on the UE type definition in RAN1, we agree with the suggestions of Ericsson and Vivo to prioritize the study on UE complexity reduction. With a better understanding of UE complexity reduction and cost saving, we can revisit the UE type definition in RAN1. |
| Moderator | **Observations:**   * Following components are considered to be included in the definition of the RedCap UE type   + Maximum supported UE BW:     - Apple, Spreadtrum, DOCOMO, ZTE, SONY (depends on the conclusion in AI 8.6.1), Intel, Huawei, HiSilicon, FUTUREWEI (depends on the study outcome), LG, vivo, Xiaomi, Qualcomm, Samsung   + Number of Rx:     - Spreadtrum, DOCOMO, ZTE (Tx/Rx), SONY (Tx/Rx), Huawei, HiSilicon, LG (or number of MIMO layers), vivo, Xiaomi, Qualcomm (Tx/Rx), Samsung   + Maximum supported MCS/modulation order:     - Huawei, HiSilicon, LG, Xiaomi   + Coverage recovery techniques for the channels in initial access:     - DOCOMO   + HD-FDD type B if supported:     - Samsung * 7 companies (Intel, Ericsson, FUTUREWEI, LG, vivo, Xiaomi, Samsung) think this should be discussed in WI phase or this discussion is not urgent   + 3 companies (Ericsson, vivo, Qualcomm) suggest focusing on the study on UE complexity reduction at first.   Based on the observations above, FL proposes to postpone the discussion until it becomes clear what complexity reduction/power saving/coverage recovery techniques are promising for RedCap UEs, and to refer to the above component list as a starting point at that time. |
| Samsung | We don’t think the question can be answered now without study and RAN 1 recommendation on what kind of feature(s) will RedCap UE supported.  In principle, we think at least the feature(s) may impact on initial access should be early reported to gNB, for example, BW, # of antenna, HD-FDD type B (if supported). However, it is not clear how many types of RedCap UE will be specified, so, it is not clear for now that whether we need to report a combination, or separated for each feature, or only 1 bit information to indicate it’s a redcap UE.  In short, we prefer to discuss this issue in late stage of SI or in WI phase when the scope of WI is clearer. |

*Companies view in contributions*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| <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**

|  |  |  |
| --- | --- | --- |
| **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 |
| Intel | Y |  |
| China Telecom | Y | This should be discussed in RAN2 first. |
| Sharp | Y | This should be discussed in RAN2. |
| CATT | Y |  |
| MediaTek | Y |  |
| Moderator | **Observation:**   * All companies commented so far support FL proposal#4   Based on the observation above, FL proposes to agree on this | |
| Sequans | Y | Maybe better to say that it is deprioritized in RAN1 until RAN2 makes some progress on the constraining mechanism. |

*Companies view in contributions*

|  |
| --- |
| <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**

|  |  |  |
| --- | --- | --- |
| **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. |
| Intel | N | We do not agree to preclude CA at this stage for RedCap UEs. As mentioned by others, and elsewhere by us, we think the option of intra-band DL CA should be considered as an optional capability for devices targeting high peak rates in the DL. |
| China Telecom | Partially Y | Agree with vivo |
| Sharp | Y | Single carrier is sufficient in the study item. |
| CATT | Partially Y | Agree with the comments that there is no need to forbid UE to support CA. |
| MediaTek | N | Agree with vivo and other companies’ views that there is no need to prevent RedCap UE from supporting CA. |
| Moderator | **Observations:**   * 17 companies (Panasonic, Qualcomm, ZTE, Xiami, Novamint, LG, InterDigital, Nokia, NSB, Ericsson, Huawei, HiSilicon SONY, Convida, Lenovo, Motorola Mobility, Sharp) support FL proposal#5 in principle * 8 companies (vivo, FUTUREWEI, DOCOMO, Samsung, Fraunhofer, China Telecom, CATT, MediaTek) think CA is not necessary to study but there is no reason not to support it * 4 companies (Spreadtrum, OPPO, CMCC, Intel) think CA can be further studied   Based on the observations above, FL updates the proposal as follows | |

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

* **Studying CA case is** **deprioritized for reduced capability UEs**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree (Y/N)** | **Comments** |
| Huawei, HiSilicon | N | According to the observation provided by Moderator, we think majority views (17 companies) don’t support CA case for RedCap UE. More importantly, as commented previously, CA increases the total concurrent UE bandwidth and requires more receiving RF chains, which is opposite to RedCap design target. Therefore we prefer the following proposal,  **Proposal**: CA is not supported for reduced capability UEs |
| Panasonic | Y with updates | Studying CA case is deprioritized for Rel.17 reduced capability UEs **study item**. |
| Nokia, NSB | Y | We are OK with the FL’s proposal. Our view is that CA can still be considered in the WI. |
| MediaTek | N | We believe this proposal is not essential, not clear how it will impact the framework which is the focus of this AI. As we mentioned there is no need to prevent RedCap UE from supporting CA.  Maybe we could rephrase it as (as proposed be some companies earlier):  “*For studying complexity reduction techniques, it is sufficient to consider only single carrier*”,  which actually is more relevant to AI 8.6.1. |
| Fraunhofer | Y | It should be clear, that this applies to the study item only. |
| FUTUREWEI | Y with updates | We are not going to have time to study CA. We can be stronger and say that it is not studied. It should be clear this is for the SI not WI as the word “studying” is present. |
| Intel | N | CA may not be necessary to be studied for baseline RedCap features, but the question of higher DL peak rates is still open, and we think options to realize larger DL BW using multiple carriers is an attractive modular (thus scalable) approach. Hence, we cannot agree to this proposal in this very generic form. |
| ZTE | Y with updates | From the observations from FL, majority companies don’t think there is a need to support CA for RedCap UE. It is very clear that CA is opposite to the intention to introduce RedCap UEs. Not sure why we need to further study it. |
| Samsung | Y |  |
| Spreadtrum | Y with updates | We share the same view with Panasonic. |
| Xiaomi | Y | If there is no strong concern from the perspective of frequency bands, we are OK with FL’s proposal |
| LG | Y | We tend to prefer the original FL proposal, but can still live with the updated FL proposal. |
| Ericsson | Y |  |
| Sequans | Y with update | We think that the intention should not be to not support CA for RedCap UEs. Neither to prevent/deprioritize study for achieving high peak rates. This should be about the study, or not, of CA as a possible axis of complexity reduction in the SI. Apparently, such study is not preferred by majority mainly due to limited available study time and also because it’s seen by some as opposite to the motivation of the SI (although we do not share this view - RedCap UE study should take into account NR devices in current market). To reflect this general preference, we think something close to MediaTek’s rephrasing of the proposal would be more accurate: e.g. “*For studying complexity reduction techniques for baseline RedCap UE, it is sufficient to consider only single carrier*” |
| DOCOMO | Y | We are fine with the update from Panasonic to clarify that CA is deprioritized in SI phase. |
| Lenovo, Motorola Mobility | Y |  |
| Sharp | Y |  |
| Moderator | **Observations:**   * 14 companies (Panasonic, Nokia, NSB, Fraunhofer, FUTUREWEI, ZTE, Samsung, Spreadtrum, Xiaomi, Ericsson, Sequans, DOCOMO, Lenovo, Motorola Mobility, Sharp) support updated FL proposal#5 in principle   + 5 companies (Panasonic, Nokia, NSB, Fraunhofer, Spreadtrum) prefer to clarify the proposal is applied to SI phase only (i.e., CA can be considered in WI phase)   + 2 companies (FUTUREWEI, ZTE) prefer not to study CA for RedCap UEs * 2 companies (Huawei, HiSilicon) prefer not to support CA for RedCap UEs * 2 companies (MediaTek, Sequans) prefer to rephrase as “For studying complexity reduction techniques (for baseline RedCap UE), it is sufficient to consider only single carrier” * 1 company (Intel) prefer not to preclude CA for higher DL peak rates   Based on the observations above, FL thinks current Updated FL proposal#5 would be good compromise and proposes to agree on this with a clarification as follows: | |

### **Further updated FL proposal#5:**

* **Studying CA case is deprioritized for reduced capability UEs in Rel. 17 SI**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | While we still do not think we need to agree on deprioritizing study of CA for RedCap, we understand companies may be concerned with available time considering that we need to focus on the mandatory set of features for RedCap first. Thus, with the understanding that this is only for the SI phase, and still does not preclude consideration of CA techniques as optional UE capabilities, we can accept Further updated FL proposal#5 |
| Qualcomm | we are fine with “Further updated FL proposal#5”, and CA study can be deprioritized for RedCap UEs in Rel. 17 SI. |
| Huawei/HiSilicon | Regarding proposal #5, we don’t feel CA will be studied in this SI. CA has more aggregated UE bandwidth than the agreed baseline bandwidth 20MHz and has higher UE complexity than single cell with 40MHz bandwidth. We don’t have agreement to support single cell with 40MHz yet, it is not appropriate to agree to study a case with even higher UE complexity, considering the complexity reduction objective in this SI. Therefore, we are sorry to say the latest proposal #5 is not agreeable to us. |
| Moderator | I think your argument is aligned with the proposal to some extent. The proposal doesn't promote us to study CA, rather it says CA is not prioritized.  Some companies prefer not to study CA, while some other prefer to open the door at this stage for further study. I think current proposal would be a good compromise among companies. Could you live with that? |
| Huawei/HiSilicon | Regarding proposal#5, we still don’t feel it is appropriate to make this decision that CA is in the study scope because CA 20+20MHz is of more complexity than single cell with 40Mhz bandwidth.  For progress, we would propose,  **Proposal #5-rev:**  *Discussion on whether to study CA case is deprioritized for reduced capability UEs in Rel. 17 SI and it will not start until maximum UE channel bandwidth is clear.* |
| LG | For the Proposal #5-rev, it’s not a strong concern but we prefer the previous one which Proposal#5 (copied below for convenience). Further updated FL proposal#5: ·         **Studying CA case is deprioritized for reduced capability UEs in Rel. 17 SI**  Otherwise, we wonder if we need the revised proposal as it doesn’t seem make much progress. |

*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**

|  |  |  |
| --- | --- | --- |
| **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. |
| Intel | Y | However, as commented by others, this is more related to 8.6.1 and 8.6.3. |
| China Telecom | Y |  |
| Sharp | Y | Coexistence issue with legacy UE for initial access should be studied. The outcome of RAN2’s study on system information should be taken into account. |
| CATT | N | It seems there is no need to discuss this issue under this AI. |
| MediaTek | Partially Y | Agree to study, need to see which AI is the best to study this. |
| Moderator | **Observations:**   * 21 companies (vivo, Panasonic, Qualcomm, Spreadtrum, ZTE, OPPO, Xiami, Novamint, InterDigital, Fraunhofer, CMCC, Nokia, NSB, Huawei, HiSilicon, SONY, Convida, Lenovo, Motorola Mobility, Intel, Sharp) support FL proposal#5 in principle * 10 companies (FUTUREWEI, DOCOMO, ZTE, Samsung, LG, Ericsson, SONY, Intel, CATT, MediaTek) think coexistence issue is related to the discussion in AIs 8.6.1 to 8.6.3 * No companies object to studying coexistence issue with legacy UE in terms of initial access   Based on the observations above, FL proposes to discuss this topic in the corresponding AIs as it is already under the discussion. | |
| Huawei, HiSilicon | Coexistence is very important and will be taken into account in the studies of AI 8.6.1-8.6.3. Since AIs 8.6.1-8.6.3 focus on reduced capability, power saving and coverage, respectively, their studies may not cover all aspects of coexistence. Based on the contribution papers, coexistence with respect to initial access procedure becomes a focus and it seems not to match with those focuses of any AI 8.6.1-8.6.3. As a result, it will not be discussed in those AI or with very low priority. In other words, coexistence issues in a clear scope that is not overlapping with AI 8.6.1-8.6.3 can be studied here. Therefore, it is preferable to study the coexistence issue in terms of initial access in AI 8.6.4. | |
| Moderator | @ Huawei, HiSilicon  Sorry for the lack of explanation, but coexistence with respect to initial access procedure is also discussed in AI 8.6.5 from access control perspective (See Section 2 in the draft summary of [102-e-NR-RedCap-05]). So, it would be very appreciated if interested companies could provide which rest of aspect in coexistence issue in initial access should be studied in AI 8.6.4 in **New question#2**. | |

### **New question#2:**

* **Which rest of aspect in coexistence issue in initial access should be studied in AI 8.6.4?**

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| **Company** | **Comments** |
| Ericsson | None. |
| Sequans | Depending on the agreed definition of “UE type” (i.e. if it is clarified to be related to access control), and the agreed initial access mechanism for RedCap UEs, the different alternatives on number of UE types may have different effect to the coexistence with legacy UE in terms of initial access. For example, we could consider if having multiple types per FR affects more the flexibility in network configuration, the access performance of legacy UEs, etc. |
| Moderator | Based on the comments so far, we can discuss coexistence issue with respect to initial access procedure in each corresponding AIs. If any additional issues which should be studied in AI 8.6.4 are identified, we can discuss further in this AI. |
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*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 |
| Intel | Agree with above comments – discussion can be deferred to a more mature stage. |
| China Telecom | Agree to discuss later |
| CATT | To be discussed later |
| Moderator | **Observation:**   * All companies commented so far think these topics can be discussed later   Based on the observation above. FL proposes to postpone the discussion on these topics in this meeting. |

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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 |
| Moderator | Considering the comments above, FL proposes to postpone the discussion on following topics in this RAN1 meeting and see RAN2 progress.   * How to define UE type for RedCap (FL proposal#1) * Whether to study additional mechanisms on top of existing UE feature/capability framework (FL proposal#2) |
| Ericsson | We are fine with FL’s proposal. |

* 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.

1. **Conclusion**

Based on the email discussion, following agreements were made.

[To be updated]

**Reference**

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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
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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
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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)