3GPP TSG RAN WG2 Meeting #115-e R2-17xxxxx

**Electronic meeting, 16th-27th August 2021**

**Agenda item:** x.x.x

**Source:** Intel Corporation

**Title:** Report of email discussion [Post114-e][105][RedCap] Capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the email discussion report for following email discussion:

* [Post114-e][105][RedCap] Capabilities (Intel)

Scope: Discuss which higher layer capabilities are not applicable for RedCap UEs and how to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc.). Can take the principles in P3.x in R2-2106528 as an initial guideline.

Intended outcome: Report (it could also result in a draft 38.306 CR)

Deadline: August 6th, 0900 UTC

**Note**: silent period is July 5-30

Rapporteur would like to split the discussion in three phases:

**Phase 1**: To discuss which higher layer capabilities are not applicable for RedCap UEs; The **deadline for this 1st phase** of email discussion is **Monday June 28st, 0900 UTC.**

**Phase 2**: To discuss how to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc., and the higher layer capabilities based on outcome from phase 1); The **deadline for this 2nd phase** of email discussion is **Monday Aug 2nd , 0900 UTC.**

**Phase 3**: To check the proposals from Rapporteur and the draft CR(s); The **deadline for this 3rd phase** of email discussion is **Friday Aug 6th , 0900 UTC.**

**Note:**

Phase 1 discussion and corresponding summary is included in section 2;

Phase 2 discussion is included in section 3;

# Phase 1- Which higher layer capabilities are not applicable for RedCap UEs

At RAN2#114-e, based on [1], [2] and [3], RAN2 discussed RedCap UE capabilities and agreed:

Working assumption:

1. Extend UE-NR-Capability using NCE to capture RedCap capabilities

Agreements:

1. We will continue the discussion on which capability are applicable to RedCap UE (FFS if we need to have an exhaustive check)

Agreements online:

1. RAN2 Working Assumption: by default, all non-RedCap UE capabilities are applicable for RedCap UE, and therefore only for non-RedCap capabilities that are not appliable for RedCap UE, we clarify in the definitions for parameters in TS38.306, the value or feature is not applicable for RedCap UE

Based on [5], CA and DC are not applied for RedCap UE.

* Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths. [RAN2, RAN1]

Based on [6], RAN2 discussed higher layer capabilities, and agreed:

Agreements via email - from offline [107]

1. Capture ‘maximum number of DRBs mandatory supported’ in the TR as one L2 capability which can be reduced for RedCap UEs.

Agreements online:

1. Capture the following in the TR on reducing total layer-2 buffer size for RedCap UEs:

“According to the calculation in TS 38.306, with peak data rate reductions, L2 buffer requirements for RedCap UEs are implicitly reduced accordingly. The need for further reduction compared to calculation in TS 38.306 needs more discussion”.

1. Capture ‘18-bit SN for PDCP and RLC AM’ in the TR as one L2 capability which can be reduced for RedCap UEs if clear benefit is identified.
2. Capture in the TR that the gain to reduce RRC processing delay needs further discussion.

The following was captured in the TR [4]:

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

At RAN2#114-e, companies had the following proposals on higher layer capabilities:

|  |  |  |
| --- | --- | --- |
| Tdoc number | Company | Related proposals and views |
| R2-2105136 | Apple | **Proposal 1: The maximum number of DRBs supported is a mandatory with signaling capability and is provided as part of UE capability for RedCap devices. Range is FFS**  **Proposal 2: The support of 18-bit SN for PDCP is optional with capability signaling for RedCap UEs.**  **Proposal 3: The support of 18-bit SN for RLC AM mode is optional with capability signaling for RedCap UEs.**  **Proposal 4: RRC processing delay requirements for RedCap UEs can be different from legacy NR UEs. FFS on the actual values.** |
| R2-2105539 | Spreadtrum | **Proposal 1: Support scalingFactor report for REDCAP UE, considering some additional smaller values or the REDCAP UE specific values to match the requirement of REDCAP UE use case better.** |
| R2-2105634 | Huawei | **Proposal 6: Consider to reduce the number of DRBs mandatorily supported by RedCap UEs.**  **Proposal 7: Consider to reduce the length of PDCP and RLC AM sequence number to be mandatorily supported for RedCap UE (e.g. mandatory 12-bit SN).**  **Proposal 8: Do not consider to further reduce the L2 buffer size calculated in TS 38.306.**  **Proposal 9: Do not consider to relax the RRC processing delay for RedCap UEs.** |

In addition, one company commented that “We could further discuss it during WI phase, e.g. DRX numbers or L2 buffer size.”.

1. Following higher layer capabilities were proposed as not applicable for RedCap UE or that some change are needed for RedCap UE;
2. Maximum number of DRBs (8 DRBs, Mandatory without UE capability signalling for non-RedCap UE); FFS on number;
3. PDCP 18bits SN (Mandatory without UE capability signalling for non-RedCap UE); FFS on mandatory SN;
4. RLC AM with 18bits SN (Mandatory without UE capability signalling for non-RedCap UE); FFS on mandatory SN;
5. L2 buffer size in TS38.306; FFS on the number;
6. RRC processing delay; FFS on the number;
7. Introduce smaller scalingFactor for RedCap UE;
8. DRX number? (Rapporteur, it is unclear whether it means the change on existing DRX number or eDRX for RedCap UE)

Based on working assumption “*by default, all non-RedCap UE capabilities are applicable for RedCap UE*”, Rapporteur believes that we do not need to go through higher layer capabilities one by one in this email discussion except those have been proposed by companies in previous meeting (above 7 higher layer capabilities). Instead, companies are invited to provide view on what higher layer capabilities are not applicable for RedCap UE.

1. Companies are invited to provide the view on above 7 higher layer capabilities. Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)

**Discussion point 1.1: Should Maximum number of DRBs to be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | We are fine to make Maximum 8 DRBs as optional feature for RedCap UE; |
| Qualcomm | Yes | We think the current requirement of maximum 8 DRBs can be relaxed for RedCap UEs.  Justifications: Each DRB requires a separate instance of PDCP/RLC. The max number of DRBs hence has a direct impact on UE’s memory size. Reducing this requirement can help reduce RedCap UE’s cost and simplify RedCap UE’s implementation.  Value for Redcap: RedCap UEs are only required to support a maximum of 4 DRBs. |
| Spreadtrum | Yes | We are ok to reduce the Maximum DRBs number for Redcap UE. |
| Lenovo | Yes | We are fine to reduce the Maximum DRB number for RedCap UE. |
| Huawei, HiSilicon | Yes | First, we’d like to clarify the current spec.   |  |  |  |  | | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | | #DRBs | The number of DRBs that a UE shall support. | 16 per UE.  NOTE 1  NOTE 3 |   NOTE 1: For one MAC entity, the maximum number of DRBs configured with PDCP duplication and with RLC entity(ies) associated with this MAC entity is 8.  NOTE 3: This requirement is applicable in NR SA, NR-DC and NE-DC. |   For legacy UE, the mandatory maximum number of DRBs is 16 rather than 8. Since there will no DRBs configured with PDCP duplication for RedCap, NOTE1 does not apply to RedCap UE.  As mentioned by Intel and QC, it is beneficial to relax the max number of DRBs for RedCap UE to reduce the memory size. Therefore, we support to reduce the supported max number of DRBs for RedCap UE.  Value for RedCap: The max number of DRBs that a RedCap UE shall support be 8. (i.e. reduced from 16->8). |
| Futurewei | Yes but… | First, we should specify a number of DRBs that all RedCap UEs shall support without a need for signaling. Supporting such specified number of DRBs is mandatory for all RedCap UEs, not optional. Hence, this is the minimum number of DRBs that all RedCap UEs shall support. In other words, if a gNB doesn’t receive additional UE capabilities information from a RedCap UE indicating that the UE supports more than the mandatory number of DRBs, this is the maximum number of DRBs that the gNB can configure for the UE.  Second, we agree with Huawei that the number of DRBs that a (non-RedCap) UE shall support is currently 16. We agree with companies that such number should be reduced for RedCap UEs. We are fine with either 4 or 8.  Third, recommend that we drop the word “maximum” and use the same expression as in the legacy text to avoid potential confusion of whether this number is a maximum number or a minimum number. |
| Ericsson | No | Agree with Futurewei that the formulation is not accurate and if the number is reduced, the number of supported DRBs shall be specified for RedCap UEs and this should be mandatory for all RedCap UEs.  However, we think this cost reduction technique is not within the scope of the WI. |
| Samsung | Yes | Agree with Huawei for the current specification, and we are fine to reduce it to 8, given the reduced bandwidth. |
| OPPO | Yes | We also think the maximum of 8 DRBs can be relaxed for RedCap UEs to reduce the size of UE memory. |
| Sequans | Yes | We think it would be beneficial to reduce the mandatory number of DRBs compared to legacy for memory size reduction.  We are fine with having 4 as mandatory minimum and 8, 16 as capabilities |
| ZTE, Sanechips | Yes | Considering maximum number of DRB is a mandatory feature for non-RedCap UEs, we are fine to relax the value for RedCap UEs (e.g. to 8). In addition, we support to make “16” as an optional feature for RedCap. |
| LGE | Yes | We are fine to reduce the Maximum DRB number for RedCap UE. |
| China Telecom | Yes | We are fine to relax the value for RedCap UEs . |
| vivo | Yes | We are fine to reduce the Maximum DRB number for RedCap UEs. |
| Nokia | Yes, but | Question is not very clear, but we are fine to reduce the Maximum DRB number for RedCap UE. |
| Apple | Yes, and | We think that the maximum number of DRBs the RedCap UE supports, **should be signaled as UE capability** (the range can be FFS) instead of an implicit number captured in the spec. The intended types of operation of RedCap UEs is diverse and so the number of DRBs needed for operation would not be uniform for all RedCap UEs. |

**Summary on the Discussion point 1.1 on reduction of maximum DRBs supported by RedCap UEs:**

16 companies provided inputs to this discussion point:

* Huawei clarified that based on TS38.306, the number of DRBs that a UE shall support is 16; Rapporteur referred to TR38.822, and therefore made a mistake on this.
* 15 companies support to reduce “the number of DRBs that a UE shall support” for RedCap UEs:
  + - “Specify the number of DRBs that a UE shall support” is supported by 5 companies (Qualcomm, Huawei, FutureWei, Ericsson, ZTE)
      * “Maximum value = 4” is supported by 3 companies (Qualcomm, Futurewei, Sequans)
      * “Maximum value = 8” is supported by 4 companies (Huawei, Futurewei, Samsung, ZTE)
    - “Optional capability to indicate the supported number” is supported by 3 companies (Apple, Sequans, ZTE)
* 1 company (Ericsson) think “this cost reduction technique is not within the scope of the WI” although they expressed that “the number of DRBs that a UE shall support” shall be specified and shall be the same for all RedCap UEs;

**Rapporteur**: propose to agree “the number of DRBs that a UE shall support” is reduced for RedCap UE. Further discussion in phase 2 on following 3 options (as related question during 1st phase was not fully clear):

* **Option 1:** On “the number of DRBs that a UE shall support”, a single mandatory value is specified for all RedCaps UEs without any optional capability signalling; FFS on what is the mandatory value, 4 or 8?
* **Option 2:** Introduce optional capability to indicate the number of DRBs that the RedCap UE supports; FFS on what is the possible value 2, 4, 8, 16?
* **Option 3:** On “the number of DRBs that a UE shall support”, a single mandatory value is specified for all RedCap UE; FFS on what is the mandatory value, 4 or 8? In addition, introduce the optional capability to indicate the number of DRBs that the RedCap can additionally support. FFS on what is possible value 8 or 16, depends on the mandatory value;

1. **[To agree] [15/16] The number of DRBs supported by RedCap UEs is less than legacy value (which is 16). FFS on the value(s).**

**Discussion point 1.2: Should PDCP 18bits SN be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. 18 bits SN is not needed for RedCap UE, but do not see what additional gain we can get by not supporting this. |
| Qualcomm | Yes | We think the mandatory length of PDCP SN field can be reduced from 18 bits to 12 bits for RedCap UEs. 18 bit SN field can be optional for RedCap UEs.  Justifications: buffer size required by PDCP/RLC depends on the width of the sliding window protocol, which in turn depends on the length of the sequence number (SN) field in their headers. For example, in RLC AM mode, the sliding window size is 2,048B when a 12 bit SN is used and 131,072B when 18 bit SN is used. On the other hand, RedCap UEs typically do not run high-throughput applications. Reducing the length of the SN field from 18 bits to 12 bits hence would not have much impact on RedCap UEs’ performance.  Value for RedCap: 12-bit mandatory; 18-bit optional. |
| Spreadtrum | Yes | We are ok for PDCP 18bits SN optional for RedCap UE. Considering the smaller maximum data rate requirement and cost reduction requirement of Redcap UE, we are also open for smaller SN values. |
| Lenovo | Yes | For RedCap UE, PDCP 18bits could be optional. We prefer a smaller value for PDCP SN based on RedCap UE application. |
| Huawei, HiSilicon | Yes | First, 18bits is definitely not necessary for RedCap.  Larger PDCP SN size will result in larger reordering window. Reducing the PDCP/RLC SN size is one quite efficient manner to reduce the higher layer memory size.  Value for RedCap: to use 12bits as mandatory, FFS for 18bits as optional or not applicable. |
| Futurewei | Yes | First, we agree to supporting PDCP 18bits SN being optional for RedCap UEs.  Second, we should make supporting PDCP 12bits SN mandatory for RedCap UEs without a need for signaling. Hence, a *longSN* parameter, instead of the *shortSN* parameter, is needed for RedCap UEs. |
| Ericsson | No | Agree with Intel |
| Samsung | No | We think the gain by reducing the SN size (including the example from Huawei) would be indeed marginal, so no need to make the current size as optional. |
| OPPO | Yes | 18 bits are not necessary for RedCap UEs. To reduce the UE memory size, we should make 18 bits as optional for RedCap UEs. |
| Sequans | Yes | We think it would be beneficial to reduce the mandatory PDCP SN size compared to legacy for reordering window size reduction.  We are fine with having 12 as mandatory minimum and 18 as a capability |
| ZTE, Sanechips | Yes | We are ok with “12-bit mandatory, 18-bit optional”. |
| LGE | Yes | We are fine to support PDCP 18-bit SN being optional, and 12-bit SN mandatory for RedCap UEs. |
| China Telecom | Yes | We are ok to support PDCP 12-bit SN mandatory for RedCap UEs. |
| Vivo | - | We are not sure whether it is related to the cost or complexity of RedCap UEs. We would like to check whether it is implicitly reduced by MIMO layer/BW? |
| Nokia | No | We agree with Intel |
| Apple | Yes | To start with, the PDCP SN size affects the window size and so affects the memory requirements for the RedCap UE for buffering the DL PDCP. We can have RedCap UEs with very minimal memory/processing capability and any removal of requirements that is not necessary for operation will help. |

**Summary on the Discussion point 1.2 on whether PDCP 18bits SN should be optional for RedCap UE:**

16 companies provided inputs to this discussion point:

* “PDCP 18 bits SN is not necessary to be supported by RedCap UEs” is supported by 11 companies (Qualcomm, Spreadtrum, Lenovo, Huawei, Furturewei, OPPO, Sequans, ZTE, LG, China Telecom, Apple )
  + Proposed values of the PDCP SN for RedCap:
    - * 12-bit mandatory is supported by 7 companies (Qualcomm, Huawei, Futurewei, Sequans, ZTE, LG, China Telecom, )
      * 18-bit optional is supported by 10 companies (Qualcomm, Spreadtrum, Lenovo, Futurewei, OPPO, Sequans, ZTE, LG, China Telecom, Apple)
      * FFS for 18bits SN as optional or not applicable (Huawei)
* “No change” is supported by 4 companies (Intel, Ericsson, Samsung, Nokia)
* FFS by vivo
* Regarding the motivation to make 18 bits SN optional, Qualcomm clarified “buffer size required by PDCP/RLC depends on the width of the sliding window protocol, which in turn depends on the length of the sequence number (SN) field in their headers. For example, in RLC AM mode, the sliding window size is 2,048B when a 12 bit SN is used and 131,072B when 18 bit SN is used.”;

**Rapporteur**: Quite some companies (11/16) support to not have mandatory support of PDCP 18 bits SN for RedCap UEs. However what value should be mandatory is not clear , and should be further discussed in phase 2:

1. **[To agree] [11/16] Not mandatory support 18 bits PDCP SN. FFS on the mandatory value;**

**Discussion point 1.3: Should RLC AM 18bits SN be optional for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. 18 bits SN is not needed for RedCap UE, but do not see what additional gain we can get by not supporting this. |
| Qualcomm | Yes | Please see our comment to Discussion Point 1.2 |
| Spreadtrum | Yes | Please refer the comments in Discussion point 1.2 |
| Lenovo | Yes | The same view as in Point1.2. |
| Huawei, HiSilicon | Yes | See our comments above |
| Futurewei | Yes | First, we agree to supporting RLC AM 18bits SN being optional for RedCap UEs.  Second, we should make supporting RLC AM 12bits SN mandatory for RedCap UEs without a need for signaling. Hence, a *am-WithLongSN* parameter, instead of the *am-WithShortSN* parameter, is needed for RedCap UEs. |
| Ericsson | No | Agree with Intel |
| Samsung | No | Same answer as in 1.2 |
| OPPO | Yes | The same view as in Point1.2. |
| Sequans | Yes | Similar to previous question |
| ZTE, Sanechips | Yes | Similar to previous question |
| LGE | Yes | Please refer the comments in Discussion point 1.2 |
| China Telecom | Yes | Similar to previous question |
| vivo | No | See 1.2. |
| Nokia | No | Agree with Intel |
| Apple | Yes | Similar reasoning as in the above question. |

**Summary on the Discussion point 1.3 on whether RLC AM 18bits SN should be optional for RedCap UE, companies have same position as PDCP 18 bits SN.**

**Rapporteur**: Quite some companies (11/16) support to not have mandatory support of RLC AM 18 bits SN for RedCap UEs. However what value should be mandatory is not clear , and should be further discussed in phase 2:

1. **[To agree] [11/16] Not mandatory support 18 bits RLC AM SN. FFS on the mandatory value;**

**Discussion point 1.4: Should L2 buffer size defined in TS38.306 be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. L2 buffer is reduced implicitly if peak data rate is reduced; |
| Qualcomm | Yes | We think reducing the requirement on the total L2 buffer size can help reduce memory size, and hence cost, of RedCap UEs.  Justifications: Although the total L2 buffer size of a RedCap UE scales down with its lower peak data rate*,* the requirement for L2 buffer size according to the current spec can still be large for low-cost devices. For example, if we assume the peak data rate for wearables are 150/50 Mbps on DL/UL and the RLC RTT is 50ms for FR1, the required total layer-2 buffer size is 1.25 MB. This is relatively large for some RedCap UEs (e.g. wearables), whose total memory typically is only a few MBs but that has to be shared among OS, apps, and other run-time procedures. On the other hand, our studies have found that good throughput can still be achieved when actual L2 buffer size is smaller than the theoretical value required by the spec, especially when data is not very bursty. Therefore, we think it is beneficial to allow RedCap UEs to choose their own preferred total layer-2 buffer size and signal that as a UE capability to network.  Value: introduce a scaling factor, which may take values of 0.25x, 0.5x, 0.75x, 1.0x, for the total L2 buffer size. |
| Spreadtrum | With comments | We agree with Qualcomm on the analysis of reducing the requirement on the total L2 buffer size for redcap UE, but we think we can keep L2 buffer size definition and equations in TS 38.306; and for the approximate maximum data rate for RedCap UE, we can follow the formula defined in TS 38.306.  However, for higher layer parameter *scalingFactor* in maximum data rate formula, we propose to change the values of *scalingFactor* for RedCap. The related motivation details is explained in the following **Discussion point 1.6**. |
| Lenovo | See comments | For redcap UE, the L2 buffer size defined in TS38.306 may be kept but with a smaller *scalingFactor.* |
| Huawei, HiSilicon | No | Since the bandwidth and maximum modulation order of RedCap UE has been reduced, the DL/UL peak data and the L2 buffer size of RedCap UE also will be reduced accordingly. The motivation of further reducing this value is not clear. |
| Futurewei | Probably no | We don’t see a strong reason for changing the current way for deriving the total L2 buffer size, except that processing time relaxation, on which we have not drawn a conclusion yet, may have a small (but possibly negligible) impact on the RLC RTT. |
| Ericsson | No | The existing calculation in TS 38.306 should be re-used, agree with Huawei comments. |
| Samsung | No | The maximum data rate would be bounded by the reduced capability (bandwidth) anyway, so the existing equation can still be used. |
| OPPO | With comments | Firstly, we prefer not to change the L2 buffer formular defined in TS 38.306. Although L2 buffer has scaled down due to reduced bandwidth for RedCap UEs, we are also ok to consider further reduction to reduce the UE memory size, e.g. by means of defining smaller *scalingFactor*. |
| Sequans | Yes | Agree with QC’s analysis that the L2 buffer size can be reduced.  FFS if a dedicated scaling factor is needed or whether it may be possible to do so only via the max data rate *scalingFactor*, as suggested by Spredtrum. |
| ZTE, Sanechips | Yes | Reducing L2 buffer size can reduce UE’s memory size, so we are open to discuss this, and extending the value range of “scalingFactor” is one way to go. |
| LGE | Yes | Similar view with Qualcomm |
| China Telecom | See comments | We are open to discuss about reducing L2 buffer size，and maybe extending the value range of “scalingFactor” is one way to go. |
| China Unicom | Yes | Similar view with ZTE, We are open to discuss this. |
| vivo | See comments | We think there is no need to change the definition of L2 buffer in TS 38.306. That is true that L2 buffer size could be reduced implicitly by reducing the peak data rate. But we also think it is related to the memory size so that related to the cost of UEs. In this way, we would like to have some discussion on the L2 buffer size of RedCap UEs, e.g. by introducing the scalling factor. |
| Nokian | No | We agree with Huawei comments. |
| Apple | Yes | We agree with the views from Qualcomm and something like a scaling factor can be introduced. |

**Summary on the Discussion point 1.4 on L2 buffer size:**

17 companies provided inputs to this discussion point:

* “L2 buffer size should be reduced” is supported by 11 companies (Qualcomm, Spreadtrum, Lenovo, OPPO, Squans, ZTE, LGE, China Telecom, China Unicom, vivo, Apple)
  + Option 1: ”Value: introduce a scaling factor, which may take values of 0.25x, 0.5x, 0.75x, 1.0x, for the total L2 buffer size”. is supported by 3 companies (Qualcomm, LGE, Apple)
  + Option 2: “keep L2 buffer size definition and equations in TS 38.306, Change the values of *scalingFactor* for RedCap (smaller scalingFactor), see discussion point 1.6” is supported by 2 companies (Spreadtrum, Lenovo)
  + 6 companies would like to continue the discussion on the details; (vivo, China Unicom, China Telecom, ZTE, Sequans, OPPO)
* “No change” is supported by 6 companies (Intel, Huawei, Futurewei, Ericsson, Samsung, Nokia)

**Rapporteur**: Although quite some companies (11/17) would like to reduce the L2 buffer size, however it is unclear how to reduce it, e.g. option 1, option 2 or other options? Note as discussed in discussion point 1.6, option 2 scalingFactor is related to RAN1 and Rapporteur suggests to leave the discussion on option 2 to RAN1.

Then it would be good to continue the discussion in phase 2 on what L2 buffer size reduction solution could be from RAN2 perspective except RAN1 related option 2 scalingFactor.

**Discussion point 1.5: Should RRC processing delay defined in TS38.331 be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

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| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. |
| Qualcomm | Yes | We think relaxed RRC processing delay requirement is good to have  Justifications: RedCap use cases do not require stringent control-plane latency. Relaxed RRC processing time allows RedCap UEs to use a simpler processor and hence lowers their costs.  Values: introduce a scaling factor, which can take the values of 1.25x, 1.5x, 2.0x, for the RRC processing delay. |
| Huawei, HiSilicon | No | The current value is more than sufficient for RedCap UE.  This will also cause impact to the NW side. The relaxation of RRC processing delay will lead to longer RRC configuration fuzzy time, which is not beneficial for the resource scheduling efficiency of the network. |
| Futurewei | No | We share the concern on the potential impacts on the NW side. |
| Ericsson | No | This would have impact on the NW side and this cost reduction technique is not in the WI scope. |
| Samsung | No | Since it has been removed the WID, no need to consider it at least for Rel-17. |
| OPPO | Yes | Agree with Qualcomm that relaxing RRC processing delay requirement is beneficial to reduce the cost for RedCap UEs. |
| Sequans | Yes | Agree that it may not be the largest contributing factor, but it could still be significant and we do not see an issue with at least using LTE times as baseline. OK to consider some scaling instead |
| ZTE, Sanechips | No | We think industrial sensor or smart watch (e.g. voice call) may have the same CP delay requirement as non-RedCap UEs. So unless strong motivation or benefit is identified, we prefer to follow the current RRC processing delay requirement for RedCap UEs. |
| LGE | No | We do not see strong reasons or benefits to relax RRC processing delay for RedCap UEs. |
| Vivo | No | We do not see the relation between RRC processing delay relaxation and cost of RedCap UEs. |
| Nokia | No | We do not see the clear motivation to make it different from non-RedCap UEs. |
| Apple | Yes | As mentioned above, atleast some of the RedCap UEs would be operating with very low cost units which can results in very high latency/low processing power HW and processing of RRC messages cannot be expected to be at part with legacy eMBB NR devices. |

**Summary on the Discussion point 1.5 on RRC processing delay for RedCap UEs:**

13 companies provided inputs to this discussion point:

* “Relax RRC processing delay for RedCap UEs” is supported by 4 companies (Qualcomm, OPPO, Sequans, Apple):
  + - “Values: introduce a scaling factor, which can take the values of 1.25x, 1.5x, 2.0x, for the RRC processing delay.” is supported by 1 companies (Qualcomm)
* “no change” is supported by 9 companies (Intel, Huawei, Futurewei, Ericsson, Samsung, ZTE, LGE, vivo, Nokia);
* Huawei raised concern from network side as “This will also cause impact to the NW side. The relaxation of RRC processing delay will lead to longer RRC configuration fuzzy time, which is not beneficial for the resource scheduling efficiency of the network.”
* Samsung and Ericsson commented that it is not in the scope of WI.

**Rapporteur**: Considering most companies (9/13) do not see the benefit to optimize the RRC processing delay for RedCap UE, and potential impact on network side. And as clarified by WI Rapporteur that it is out of scope. Rapporteur suggests:

1. **[To agree] [9/13] “RRC processing delay” is not relaxed for RedCap UE.**

**Discussion point 1.6: Should smaller scalingFactor be introduced for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs. In addition, it is unrelated to higher layer capability. |
| Qualcomm | No | If this *scalingFactor* refers to the one for scaling the max data rate defined in Clause 4.1.2 in TS38.306, then we do not support it. We do not think it is a right approach to reduce memory size by reducing max data rate. As RedCap UEs already has lower data rates, memory size should be reduced by a separate scaling factor so that max data rate is not affected. |
| Spreadtrum | Yes | In Rel-15/16, *scalingFactor* is an UE capability reported to network, which is used to determine the max data rate. And the scaling factor is given by higher layer parameter *scalingFactor* and can take the values 1, 0.8, 0.75, and 0.4 in TS 38.306.  Based on the conclusion from RAN2#114 meeting, by default, all non-RedCap UE capabilities are applicable for RedCap UE.  However, as Rel-17 RedCap supports three use cases with quite different data rate requirements, e.g. less than 2 Mbps for industrial wireless sensor, and up to 150 Mbps for wearables, the current values of scaling factor non-RedCap UE for is not well matched the three use cases for RedCap, and the different scaling factor values for RedCap UE is necessary, e.g {1, 0.75, 0.4, 0.1}. In addition, we propose *scalingFactor* to be mandatory for RedCap UE. |
| Lenovo | Yes | Same view as Spreadtrum, a smaller scalingFactor could be introduced for RedCap UE. |
| Ericsson | No | As mentioned, smaller *scalingFactor* is already possible to use. Also in our understanding this has been discussed in RAN1 already and this discussion is not in RAN2 scope. |
| Samsung | No | The reason to introduce *scalingFactor* before was mainly due to the mismatch between RF and baseband capabilities, and the data rate ata rate would be bounded by the bandwidth anyway, so perhaps no need to update it for RedCap. |
| OPPO | - | It’s not clear what this smaller scalingFactor is used for. If for L2 buffer, we are ok to consider it. |
| Sequans | Yes | We agree additional values could be useful, regardless of question 1.4 |
| ZTE, Sanechips | Yes | Ok to introduce smaller scalingFactor values. But we don’t think the feature should be mandatory for RedCap UEs. |
| LGE | Yes | We are fine to introduce smaller scalingFactor for RedCap UEs. |
| China Telecom | Yes | We are fine to introduce smaller scalingFactor for RedCap UEs. |
| China Unicom | Yes | We are fine to introduce smaller scalingFactor, and the issue on whether it should be mandatory or optional for RedCap UEs can be further discussed. |
| vivo | Yes | We are fine to introduce smaller scalling factor values, e.g. for reduced L2 buffer size. |
| Nokia | No | We are fine to introduce smaller scalling factor values, e.g. for reduced L2 buffer size. |
| Apple | Yes | we see the usefulness of this for reasons mentioned above |

**Summary on the Discussion point 1.6 on small scalling factor values for RedCap UEs:**

15 companies provided inputs to this discussion point:

* “Introduce smaller value for “*scalingFactor*”” is supported by 9 companies (Spreadtrum, Lenovo, Sequans, ZTE, LGE, China Telecom, China Unicom, vivo, Apple)
  + - “new Values: 0.75, 0.1.” is supported by 1 company (Spreadtrum,)
    - *scalingFactor* is mandatory for RedCap UE:
      * *Yes,* (Spreadtrum,)
      * *No, (ZTE, )*
      * *FFS (China Unicom)*
* “no” is supported by 5 companies (Intel, Qualcomm, Ericsson, Samsung, Nokia);
* Ericsson commented “this has been discussed in RAN1 already and this discussion is not in RAN2 scope.”

**Rapporteur**: The issue is related to discussion point 1.4 L2 buffer size reduction. Considering scaling factor was introduced by RAN1 to resolve the mismatch between RF and baseband capabilities, and RAN1 has discussed it. It would be good to avoid the duplicated discussion in different WGs for the same topic, especially there is no majority in RAN2 to take any decision. Rapporteur suggests to leave this discussion to RAN1.

1. **[To agree] Leave the discussion on “small scalling factor values for RedCap UEs” to RAN1.**

**Discussion point 1.7: Should DRX defined for non-RedCap UE be changed for RedCap UE?** **Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | We do not see the clear motivation to make it different from non-RedCap UEs, especially considering eDRX will be introduced for RedCap UE. |
| Qualcomm | No |  |
| Lenovo | No |  |
| Huawei, HiSilicon | No |  |
| Futurewei | No |  |
| Ericsson | No | Not clear to us what is exactly being proposed and why. |
| Samsung | No | - |
| OPPO | No |  |
| Sequans | No |  |
| ZTE, Sanechips | No |  |
| LGE | No |  |
| China Telecom | No |  |
| vivo | No | Actually, we do not know exactly what this proposal means. |
| Nokia | No |  |
| Apple | No | And we did not fully understand this as well. |

**Summary on the Discussion point 1.7 on DRX:**

**Regarding companies’ question on what exactly the proposal means?** Rapporteur also is no clear on what it is. The reason it has been added here because the issue was raised in previous offline discussion. one company commented that “We could further discuss it during WI phase, e.g. DRX numbers or L2 buffer size.”.

1. Are there any other higher layer capabilities not applicable for RedCap UE? Please justify your response (please also indicate the details, e.g. not mandatory, changed value/value range, etc.)

|  |  |
| --- | --- |
| **Company’s name** | **Companies’ views** |
| Huawei, HiSilicon | * Following proposals should also be agreed:   + Any capabilities related to MR-DC do not apply to RedCap UE.   + Any capabilities related to CA do not apply to RedCap UE.   [Rapporteur] This should already be clear based on the WID  “*Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths. [RAN2, RAN1]*” But agree, it would be good to confirm whether NE-DC, (NG)EN-DC are supported or not.   * In addition, we propose the ANR feature should be optional for RedCap UE (instead of mandatory as for non-RedCap UE). It is sufficient to rely on non-RedCap UEs to support the ANR from the NW perspective. No need to further mandatorily request RedCap UE to perform ANR, which cause a lot complexity.   [Rapporteur] Proposal sounds reasonable. But would be good to confirm in phase 2 discussion.   * We also want to clarify this email discussion does not touch the R16 feature yet. We may need to postpone the discussion on whether any R16 feature does not apply to RedCap UE.   [Rapporteur] The intention of this discussion is to cover both Rel-15 and Rel-16. If you have anything in mind, pls raise it here. |
| Sequans | Agree with HW |
| ZTE, Sanechips | 1. All CA, DC related capabilities are not applicable to RedCap UEs. And there are multiple functions have defined capabilities related to CA/DC, so they should be picked out carefully (if clarification will be made in field description).   [Rapporteur] Agree, we need to check specification carefully. Please see our thinking in phase 2 discussion on how to handle it.   1. We are not sure whether RedCap devices can support access to LTE or UTRAN system? If not, then inter-RAT mobility related capabilities are not applicable to RedCap UEs.   [Rapporteur] This would be good to confirm in phase 2 discussion.   1. For measurement related capabilities, e.g. maxNumberCSI-RS-RRM-RS-SINR, the current value range is {n4, n8, n16, n32, n64, n96}, while the larger values (e.g. n64, n96) require high UE complexity thus we think are not applicable to RedCap UEs.   [Rapporteur] This would be good to confirm in phase 2 discussion.   1. We think this email discussion should involve R16 features, unless we change the Working Assumption for R16 features (i.e. all R16 and R16+ features are not applicable to RedCap by default).   [Rapporteur] yes, you are right. The email discussion also covers R16 feature.   1. On the other hand, it is unclear whether some Rel-16 features (e.g. URLLC, V2X, IAB) are applicable to RedCap due to reduced BW/Rx. For instance, whether additional RAN1/4 requirements should be defined for reduced BW/Rx case? Probably we need to consult with other feature’s expert for confirmation.   [Rapporteur] would be good to confirm in phase 2 discussion. |
| vivo | According to RAN2 conclusion below and before   1. RAN2 Working Assumption: by default, all non-RedCap UE capabilities are applicable for RedCap UE, and therefore only for non-RedCap capabilities that are not appliable for RedCap UE, we clarify in the definitions for parameters in TS38.306, the value or feature is not applicable for RedCap UE   We think only features related to DC/CA are not applicable for RedCap UEs. But the others should be applicable for RedCap UEs by default. |
| Nokia | Any capabilities related DC or CA should not be applicable to RerCap according to WID |
| Apple | CA and DC to start with. We have to discuss Rel-16 additionally as well.  [Rapporteur] The intention of this discussion is to cover both Rel-15 and Rel-16. If you have anything in mind, pls raise it here. |

Rapporteur, during phase 1 discussion, following features were raised by companies, and will be discussed in phase 2:

* + - ANR feature should be optional for RedCap UE (instead of mandatory with capability signalling as for non-RedCap UE).
    - whether RedCap devices can support access to LTE or UTRAN system? If not, then inter-RAT mobility related capabilities are not applicable to RedCap UEs.
    - For measurement related capabilities, e.g. maxNumberCSI-RS-RRM-RS-SINR, the current value range is {n4, n8, n16, n32, n64, n96}, while the larger values (e.g. n64, n96) require high UE complexity thus we think are not applicable to RedCap UEs.
    - it is unclear whether some Rel-16 features (e.g. URLLC, V2X, IAB) are applicable to RedCap due to reduced BW/Rx. For instance, whether additional RAN1/4 requirements should be defined for reduced BW/Rx case? Probably we need to consult with other feature’s expert for confirmation.

In addition, Rapporteur would like to clarify here, the email discussion intends to cover R16 features.

# Phase 2

## Leftover issues from Phase 1

**Phase 2-Discussion point 1.1 on reduction of maximum DRBs supported by RedCap UEs:**

* **Option 1:** On “the number of DRBs that a UE shall support”, a single mandatory value is specified for all RedCaps UEs without any optional capability signalling; FFS on what is the mandatory value, 4 or 8?
* **Option 2:** Introduce optional capability to indicate the number of DRBs that the RedCap UE supports; FFS on what is the possible value 2, 4, 8, 16?
* **Option 3:** On “the number of DRBs that a UE shall support”, a single mandatory value is specified for all RedCap UE; FFS on what is the mandatory value, 4 or 8? In addition, introduce the optional capability to indicate the number of DRBs that the RedCap can additionally support. FFS on what is possible value 8 or 16, depends on the mandatory value;

**Phase 2-Discussion point 1.1: Companies are invited to provide your view on how to reduce the maximum DRBs supported by RedCap UE, i.e. which option is preferred, and corresponding value**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, 2, 3?**  **Mandatory value 4, 8?**  **Optional value 2, 4, 8, 16?** | **Comments, if any** |
| Intel | Option 1, Mandatory value 8 | It would be good to keep the principle the same as non-RedCap UE. Do not see the reason why it should be optional, especially considering the fixed mandatory value should be sufficient. |
| ZTE, Sanechips | Option 3 with mandatory 8; | We prefer to at least define a mandatory value (e.g. 8) for all RedCap UEs.  But Option 1 is also acceptable to us. In our understanding, Option 1 means if needed, larger values can be introduced (as optional feature) in the future. |
| Apple | Option 2 | The use-case requirements for RedCap devices have a wide range and it’s not beneficial to mandate 8 DRBs for all RedCap. For example, for video surveillance, there is no need for 8 DRBs when the device is just to intended to feed video/audio in the uplink. But dimensioning the HW/SW to handle 8 DRBs results in unnecessary requirements for these type of UEs.  Option -2 by allowing the RedCap UE to report as capability is a better option And while we understand the additional handling at the NW, we can start with a minimum mandatory DRB value (for eg 2 as in option 2) that the rapporteur proposed. |
| Huawei, HiSilicon | Option 1, Mandatory value 8 | Single mandatory value will make the gNB implementation much simpler.  Also agree with Intel. |
| OPPO | Option 3 with mandatory 8; | Option 3 is more flexible. |
| Spreadtrum | Option 2 | Share the similar view with Apple, considering R17 RedCap will support three use cases, which have very different requirements. |
| Qualcomm | Option 3 | We think Option 3 is the most flexible one among the three, which can accommodate RedCap UEs with a wider range of capabilities.  As the mandatory value, so far we have rarely seen a UE being configured with more than 4 DRBs in the field. Hence it is unclear to us what use cases would require RedCap UE to support more than that. Just in case there are future use cases that require more than 4 DRBs, Option 3 is a good way to ensure future compatibility. |
| Sierra Wireless | Option 1, Mandatory value 8 | Similar view as Intel |
| Futurewei | Option 1, Mandatory value 8 | But we are also open to Option 3, with mandatory value 4, in which case, if a UE supports more than 4 DRBs, the UE indicates the maximum number of DRBs that it supports in UE capability. |

**Phase 2- Discussion point 1.2 on whether PDCP/RLC AM 18bits SN should be optional for RedCap UE**

**During phase 1 discussion, there are different options:**

* **Option 1:** PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, and PDCP/RLC AM 18bits SN is not supported by RedCap UE;
* **Option 2:** PDCP/RLC AM 12 bits SN is mandatory for RedCap UE, and PDCP/RLC AM 18bits SN is optional supported by RedCap UE;

**Phase 2-Discussion point 1.2: Companies are invited to provide your view on which option is preferred?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, option 2?** | **Comments, if any** |
| Intel | Option 1 | As clarified by Qualcomm in phase 1, the additional gain is to reduce the sliding window size, and therefore we can accept this. Same comments as discussion point 1.1-phase 2, It would be good to keep the same principle as non-RedCap UE. Do not see the reason why it should be optional, especially considering the fixed mandatory value should be sufficient. |
| ZTE, Sanechips | Option 2 | We think it is necessary to allow (high-end) RedCap UEs to indicate the support of 18 bits SN, so Option 2 is preferred. |
| Apple | Option 2 | We are also ok wth option-1, but op-2 is better for flexibility. |
| Huawei, HiSilicon | Option 2 | Option 2 can be the compromise to support more use cases. |
| OPPO | Option 2 | Option 2 is more flexible. |
| Spreadtrum | Option 2 | Considering to support more use cases. |
| Qualcomm | Option 2 | We prefer Option 2 over Option 1 for its better flexibility, which is the same reason in our comment on Discussion Point 1.1. |
| Sierra Wireless | Option 1 |  |
| Futurewei | Option 2 | We prefer to have the flexibility for supporting 18 bits. |

**Phase 2- Discussion point 1.4 on L2 buffer size reduction.**

**During phase 1 discussion, there are different options:**

* + **Option 1**: ”Value: introduce a scaling factor, which may take values of 0.25x, 0.5x, 0.75x, 1.0x, for the total L2 buffer size”.
  + **Option 3** no change, i.e. keep L2 buffer size definition and equations in TS 38.306
  + **Option 4** others.

**As proposed in phase 1 discussion** option 2 scalingFactor is related to RAN1 and should be discussed in RAN1. Therefore Rapporteur would like to check companies ‘s view whether option 1, 3 or option 4 should be considered;

* + Option 2: “keep L2 buffer size definition and equations in TS 38.306, Change the values of *scalingFactor* for RedCap (smaller scalingFactor), see discussion point 1.6” is supported by 2 companies

Note: Option 2 should be discussed in RAN1, and therefore is not considered in phase 2 discussion.

**Companies are invited to provide view on which option is preferred from RAN2 perspective.**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, option 3**  **Option 4** | **Comments, if any** |
| Intel | Option 3 | As commented in phase 1 discussion, from RAN2 perspective, we do not see the need to have any change for L2 buffer size reduction. |
| ZTE, Sanechips | Up to RAN1 to decide | From RAN2 perspective, we see no big difference between “introducing a new scalingFactor (Option 1)” and “extending the value range of existing scalingFactor (Option 2)”, if anyway the scalingFactor will be used to calculate the peak data rate. (We think network does not need to care whether the scaling is caused by mismatch between RF and baseband capability, or caused by other reasons)  However, if companies think the usage and value range of existing scalingFactor should be discussed in RAN1, we are fine to leave the whole discussion to RAN1. |
| Apple | Some clarification is sought.  Option-2 where RAN2 discusses the scaling factor for L2 buffer size (which is not related to the current scaling factor of RAN1) | It is our understanding that the scaling factor discussion here is on the L2 buffer (using a similar logic as the RAN1 SF). So here the 0.25x/0.5x etc is on the fraction of the total L2 buffer size the RedCap UE is expected to support, based on the 38.306 L2 buffer size calculation. |
| Huawei, HiSilicon | Option 3 | Regardless the discussion in R1, the sentence “*keep L2 buffer size definition and equations in TS 38.306*” in option 3 should be correct, since option1 seems RAN2 scope. |
| OPPO | Up to RAN1 to decide | We hold the same understanding as ZTE that option 1 and 2 are in principle the same. We agree that scalingFactor should be discussed in RAN1, but RAN1 may not discuss this without RAN2’s request. So we propose to send LS to RAN1. |
| Spreadtrum | Option 2 with comments | Firstly, from Rapporteur’s observation, quite some companies (11/17) would like to reduce the L2 buffer size. According to Phase 1 discussion (point 1.4&1.6) on L2 buffer size reduction, we suggest a working assumption that for Rel-17 RedCap UE, the reduction of L2 buffer size is needed.  Secondly, what L2 buffer size reduction solution should be discussed based on working assumption. At Phase 2, we think it should be fair to compare different solutions mentioned in Phase 1 discussion in one complete picture including Option 2. We share the same view with Apple that Option-2 where RAN2 discusses the scaling factor for L2 buffer size (which is not related to the current scaling factor of RAN1). In addition, we don’t think it will duplicate discussion in different WGs, as RAN2 will focus on L2 buffer size reduction, and RAN1 will resolve the mismatch between RF and baseband capabilities. So, the following four options should be fairly discussed at Phase 2 together:   * **Option 1**: ”Value: introduce a scaling factor, which may take values of 0.25x, 0.5x, 0.75x, 1.0x, for the total L2 buffer size”. * **Option 2**: introduce a smaller scalingFactor value for RedCap UE while keep L2 buffer size definition and equations in TS 38.306. * **Option 3** no change, i.e. keep L2 buffer size definition and equations in TS 38.306 * **Option 4** others. |
| Qualcomm | Option 1 | There is a difference between Option 1 and 2: Option 1 reduces L2 buffer size **without** scaling down max data rate, whereas Option 2 reduces L2 buffer size **through** scaling down max data rate. We do not think it is desirable to scale down the max data rate, which is already smaller for RedCap UEs. That would reduce UE’s throughput and indirectly impact UE’s power savings. |
| Sierra Wireless | Option 3 | No need to change the L2 buffer size definition or introduce new scalingFactor for Rel-17. Can be considered for Rel-18. |
| Futurewei | Option 3 | We do not see a need to change from RAN2’s perspective. |

**Phase 2-Discussion point 2.1: Should ANR feature be optional for RedCap UE (instead of mandatory with capability signalling as for non-RedCap)?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Looks reasonable. We should leave the freedom to RedCap UE on whether to support it. |
| ZTE, Sanechips | Yes with comments | We are fine to change it to optional feature for RedCap UEs.  But, it is possible to deploy RedCap specific cells, and ANR function will be useful in that case. So if operators prefer to keep ANR as mandatory feature (with IoT bit) for RedCap Ues, it is also acceptable for us. |
| Apple | Yes |  |
| Huawei, HiSilicon | Yes | Even in RedCap only cell (which was not agreed in last meeting), some RedCap Ues can optionally support ANR to assist operators. |
| OPPO | Yes |  |
| Spreadtrum | Yes | It is benefit for network optimization. |
| Qualcomm | Yes | ANR does require extra complexity in UE implementation. And network can reply on non-RedCap UEs to perform ANR. |
| Sierra Wireless | Yes |  |
| Futurewei | Yes |  |

**Phase 2-Discussion point 2.2: Should inter-RAT mobility related capabilities be applicable to RedCap UEs, e.g. to LTE/UTRAN?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Anyway, it is an optional feature. If it is complex to some RedCap UEs, then those RedCap UEs will not support it. But do not see the reason why we need to forbid the RedCap UE to support this. |
| ZTE, Sanechips | Yes with comments | Thanks for adding this question to Phase 2 discussion.  We would like to clarify that our intention is not to **disallow** UE from supporting inter-RAT mobility feature. From standard point of view, we have to ensure the function/requirement defined in RAN1/2/4 are **complete** for RedCap UEs.  From RAN2 perspective, we think it is useful to support inter-RAT mobility for RedCap UEs (e.g. wearable devices). However, we are not sure the current RAN4 requirement (for non-RedCap UE) can be applicable to RedCap UEs or not? E.g. handover delay requirement defined in TS 38.133. So it is better to check with RAN4. |
| Apple | Yes with comments | We agree with ZTE’s view and it is our view that we should ensure that RAN4 does discuss this (either with an LS to RAN4, or company contribution). We think RAN2 LS to RAN4 would be better, as the RAN4 current plan does not seem to have this. |
| Huawei, HiSilicon | Yes | As long as RAN2 agree the proposal, other WGs can do their jobs to ensure the feature works for RedCap. |
| OPPO | Yes | Agree with above companies that RAN2 should not have any limitation. It is based on capability indication. |
| Spreadtrum | Yes | It is benefit to support inter-RAT mobility for RedCap UE. And we share the similar view to check with other group. |
| Qualcomm | Yes | Inter-RAT mobility can help RedCap UEs maintain good service coverage, which is useful. So it can remain a UE capability for RedCap UEs that can support two RATs. |
| Sierra Wireless | Yes | No reason to forbid it and may be needed for initial deployments. |
| Futurewei | Yes … | as long as it is kept optional. |

**Phase 2-Discussion point 2.3: - For measurement related capabilities, maxNumberCSI-RS-RRM-RS-SINR, the current value range is {n4, n8, n16, n32, n64, n96}; Should the larger values (n64, n96) be applicable to RedCap UEs?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Anyway, it is optional feature. If it is complex to some RedCap Ues, then those RedCap Ues will not support it. But do not see the reason why we need to forbid the RedCap UE to support this. |
| ZTE, Sanechips | No | Thanks for adding this question to Phase 2 discussion.  Please note “CA/DC capabilities” are also optional features, and we preclude them explicitly.  We suggest to preclude larger values because we think those may never be supported for RedCap Ues (due to reduced capability), so the values range for RedCap Ues should only include reasonable values.  And TR 38.875 has captured following case as one category, so we think it is our responsibility to ensure the value range defined for RedCap is reasonable and feasible.   * For the features that are optional for non-Redcap Ues:   - The Redcap UE does not support the feature at all.  - The Redcap UE supports the feature with a different value;  - The Redcap UE supports the feature with the same value;  - The Redcap UE mandatorily supports the feature  In addition, the proposal also applies to other measurement related capabilities (if CLI is supported for RedCap UE):  maxNumberCLI-RSSI-r16 ENUMERATED {n8, n16, n32, n64} OPTIONAL,  maxNumberCLI-SRS-RSRP-r16 ENUMERATED {n4, n8, n16, n32} OPTIONAL, |
| Apple | Yes | They are optional. We may need RAN1 to confirm as well. |
| Huawei, HiSilicon | Yes, maybe | We are not sure this can be discussed in RAN2.  Meanwhile, we also agree with the rapporteur. |
| OPPO | Yes | The only motivation for removing larger values is to support optional features with different value ranges and to saving signaling overhead. Reusing the same value range for optional features is also acceptable to us. |
| Spreadtrum |  | We may need to leave it to RAN1. |
| Qualcomm | - | It is an optional feature for non-RedCap UEs. It can remain that way for RedCap UEs too |
| Futurewei | Yes … | as long as it is kept optional. |

**Phase 2-Discussion point 2.4: For Rel-16 features, should URLLC be applicable for RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Anyway, it is optional feature. If it is complex to some RedCap UEs, then these RedCap Ues will not support it. But do not see the reason why we need to forbid the RedCap UE to support this. However, we agree that the impact due to reduced BW/Rx should be checked by RAN1/4. |
| ZTE, Sanechips | Yes with comment | We think URLLC function can be applicable to RedCap UE, but it is unclear whether current RAN1 spec and RAN4 requirement (e.g. UE demodulation performance requirements) can be directly reused or not. It is better to check with RAN1/4. |
| Apple | Yes, but to check with RAN1/RAN4 as well. |  |
| Huawei, HiSilicon | Yes | See no reason to exclude this feature for RedCap UE |
| OPPO | Check with RAN1/4 | This should be discussed in RAN1/4 first. |
| Spreadtrum | Yes | To keep more flexibility to cover more use case. |
| Qualcomm | - | All R16 features are optional features. Whether to support any of them is already UE capability. So URLLC can be a UE capability for RedCap UEs too. |
| Futurewei | Yes … | as long as it is kept optional. |

**Phase 2-Discussion point 2.5: For Rel-16 features, should V2X be applicable for RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Anyway, it is optional feature. If it is complex to some RedCap UEs, then these RedCap Ues will not support it. But do not see the reason why we need to forbid the RedCap UE to support this. However we agree that the impact due to reduced BW/Rx should be checked by RAN1/4. |
| ZTE, Sanechips | No | We think current V2X/Sidelink function **without any enhancement** cannot be applied to RedCap Ues, because:   * + - 1. V2X Mode 1 operation requires Uu carrier to schedule SL carrier, so UE has to support 2 CCs operations, one is for sidelink scheduling via Uu another is for sidelink transmission. This does not fit the “single CC” requirement defined for RedCap.       2. Except Mode 1 operation, for backward compatibility, RedCap UE is expected to communicate with legacy V2X/sidelink UE which is out of coverage, in this case, the Redcap UE is required to support the bandwidth same as legacy V2X UE that is preconfigured. So in order to align the preconfigured parameters with the configuration for RedCap UE, it would greatly restrict the deployment of the Rel-16 V2X. Besides, the capability exchange between legacy UE and RedCap UE is not supported in Rel-16.       3. As we know, in Rel-17, only three bands are specified for V2X use only, and RAN4 has no plan to discuss and define requirements for RedCap UE to support V2X/Sidelink function.   So we don’t think existing V2X/Sidelink function/capabilities can be directly reused for RedCap, it is better to discuss and specify it in Rel-18 (as already proposed by companies during Rel-18 workshop). |
| Apple | Can be allowed | They are optional anyway. But we do agree with ZTE’s comments that some modification would be needed. |
| Huawei, HiSilicon | See comments | If companies have different views on this feature, the compromise is to not have any proposal at all, i.e. neither to forbid the feature nor to explicitly say this feature can be supported by RedCap without any extra spec impact. |
| OPPO | Check with RAN1/4 | This should be discussed in RAN1/4 first. |
| Spreadtrum | Yes | Agree with Huawei. |
| Qualcomm | - | In principle, we think V2X can be a UE capability for RedCap UEs too. But agree with Intel that the feasibility of supporting it on reduced BW should be checked by RAN1/4. |

**Phase 2-Discussion point 2.6: For Rel-16 features, should IAB be applicable for RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes | Anyway, it is optional feature. If it is complex to some RedCap UEs, then these RedCap UEs will not support it. But do not see the reason why we need to forbid the RedCap UE to support this. However we agree that the impact due to reduced BW/Rx should be checked by RAN1/4. |
| ZTE, Sanechips | No | RedCap UE has limited bandwidth and limited Rx branches. **It does not make sense to use RedCap device to deploy IAB-MT (gNB-DU)**, because IAB-MT needs to provide access for multiple UEs.  In addition, two types of IAB are defined in RAN4, wide-area IAB and local area IAB, different RF requirements are defined for each type. As we know, RAN4 has no plan to discuss and define requirements for IAB-MT to meet the requirements of RedCap UE.  So we think all capabilities defined for IAB-MT are not applicable to RedCap UEs. |
| Apple | Neutral | As mentioned above, we would atleast need modifications. We are not sure if we have enough TUs in RAN2/1/4. |
| Huawei, HiSilicon | No | IAB is not a feature. IAB-MT is new UE-like device.  We are not sure about the question. Do it mean “whether IAB-node can implement RedCap UE replacing IAB-MT”? |
| OPPO | No | We see no use case and motivation to support IAB function for RedCap UEs. |
| Spreadtrum | No | Agree with ZTE that, it does not make sense to use RedCap device to deploy IAB-MT (gNB-DU). |
| Qualcomm | No | Not sure if anyone would run IAB over reduced BW. |
| Futurewei | No | It makes no sense because the power/cost would-be-saved by using a RedCap UE as the IAB-MT is so marginal comparing to the power/cost on the IAB-DU side, not mentioning the loss in performance. |

**Phase 2-Discussion point 2.7:**

In the WID, only CA and DC were mentioned. It is not 100% clear whether NE-DC, (NG)EN-DC are supported or not. It would be good to confirm here.

**Companies are invited to provide your view on whether NE-DC, (NG)EN-DC are supported by RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | To support NE-DC, (NG)EN-DC, multiple CCs shall be supported, i.e. CA like. Same as the reason not support CA and DC, to reduce complexity for RedCap UE, NE-DC, (NG)EN-DC shall not be supported. |
| ZTE, Sanechips | No | We think the term “DC” mentioned in WID includes all MR-DC cases. |
| Apple | No |  |
| Huawei, HiSilicon | No |  |
| OPPO | No |  |
| Spreadtrum | No |  |
| Qualcomm | No | We think the “DC” in the WID includes any types of DC, which includes NE-DC and (NG)EN-DC. |
| Sierra Wireless | No | Agree with ZTE |
| Futurewei | No |  |

**Phase 2-Discussion point 2.8:**

In the WID, only CA and DC were mentioned as features not to support by RedCap UEs. Rapporteur think we also need to check whether R16 mobility, e.g. DAPS, Conditional Pscell change are supported for RedCap UE.

**Companies are invited to provide your view on whether the features introduced by Rel-16 mobility, DAPS handover and Conditional Pscell change are supported by RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | No | DAPS cannot be supported by RedCap UE. For conditional Pscell change, at least conditional Pscell change for SCG cannot be supported. |
| ZTE, Sanechips | No | Same view as Intel.  But we think normal PCell CHO is applicable to RedCap UE. |
| Apple | No |  |
| Huawei, HiSilicon | No, but | Those features can be considered as CA/DC related.  It should be feasible to support CHO for RedCap UE. |
| OPPO | No |  |
| Spreadtrum | No, but | We think only normal PCell CHO is applicable for RedCap UE. |
| Qualcomm | No | DAPS and conditional PSCell change require the same level of complexity in UE implementation as that for DC. So RedCap UEs should not be required to support them either. |
| Futurewei | No for DAPS | We are OK with optional support of CHO. |

**Phase 2-Discussion point 2.9: Any other Rel-15/Rel-16 features should not be supported by RedCap UE? Please justify your response ( Please also indicate the details, e.g. not mandatory, changed value/value range, etc.)**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| ZTE, Sanechips |  | Positioning.  We think Positioning function is useful for some use cases of RedCap, e.g. children’s smart watch. And we are aware that some companies are proposing to discuss the enhanced solution of positioning for RedCap in Rel-18. Regarding Rel-16/Rel-17 positioning, it is better to check with RAN1/4 about the applicability of Positioning for RedCap UE. |
|  |  |  |
|  |  |  |

## How to reflect the handling of RedCap specific capabilities

How to reflect the handling of RedCap specific capabilities (e.g. Maximum BW, Max Rx, MIMO-Layer, 256QAM, CA/DC, HD-FDD, etc.). Can take the principles in P3.x in R2-2106528 as an initial guideline.

|  |
| --- |
| **P3.x in R2-2106528**  Proposal 3.1. [To discuss] [15/25]  Revised Principle 1: For RedCap UE’s mandatory without signaling features:  which are optional or mandatory with capability signaling for non-RedCap UE, clarify in TS 38.306 in the definitions for existing parameters; Note “existing” is related to proposal1.  which are mandatory without capability signaling but with different value(s) for non-RedCap UE, clarify in TS 38.306 in the definition for new RedCap UE (FFS on new RedCap capability, type, etc); FFS on the need of new section  Proposal 3.2. [To discuss] [19/25] Principle 2.For RedCap UE’s optional features, which are mandatory without capability signaling for non-RedCap Ues (if any), or newly introduced in R17 for RedCap, add new UE capability signaling in TS 38.331 and capture the new definition in TS 38.306; FFS on the need of new section;  Proposal 3.3. [To discuss] [16/25] Revised Principle 3. For RedCap UE’s optional features, which are optional for non-RedCap UE but with different value (if any), extend the legacy capability signaling, and also capture the restriction in the definitions for existing parameters in TS 38.306; Note “existing” is related to proposal1.  Proposal 3.5. [To discuss] [16/25] Revised Principle 5. For the features not applicable to RedCap UE but mandatory without capability signaling supported by non-RedCap UE, clarify in TS 38.306 in the definition for new RedCap UE (FFS on new RedCap capability, type, etc). FFS on the need of new section; |

### Phase 2-Discussion point 3.1: How to capture Maximum BW;

According to the WID [5], the maximum UE bandwidth for FR1 is 20Mhz, and 100Mhz for FR2:

* + *Reduced maximum UE bandwidth:*
    - *Maximum bandwidth of an FR1 RedCap UE during and after initial access is 20 MHz.*
    - *Maximum bandwidth of an FR2 RedCap UE during and after initial access is 100 MHz.*

As mentioned in [7], so far the Bandwidth is reflected by *channelBWs-DL* in IE *RF-Parameters* and *supportedBandwidthDL* in *FeatureSetDownlinkPerCC*;

To capture the restriction on bandwidth for RedCap UE, the field description of *channelBWs-DL* and *supportedBandwidthDL* should be updated;

#### TS38.306 TP on Maximum Bandwidth:

#### 4.2.7.2 *BandNR parameters*

/\*\*\* omitted unrelated parts\*\*\*/

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***channelBWs-DL***  Indicates for each subcarrier spacing the UE supported channel bandwidths. Absence of the *channelBWs-DL* (without suffix) for a band or absence of specific scs-XXkHz entry for a supported subcarrier spacing means that the UE supports the channel bandwidths among [5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100] and [50, 100, 200] that were defined in clause 5.3.5 of TS 38.101-1 version 15.7.0 [2] and TS 38.101-2 version 15.7.0 [3] for the given band or the specific SCS entry. For IAB-MT, to determine whether the IAB-MT supports a channel bandwidth of 100 MHz, the network checks c*hannelBW-DL-IAB-r16*.  For FR1, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 5, 10, 15, 20, 25, 30, 40, 50, 60 and 80MHz. For FR2, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 50, 100 and 200MHz. The third / rightmost bit (for 200MHz) shall be set to 1. For IAB-MT the third / rightmost bit (for 200MHz) is ignored. To determine whether the IAB-MT supports a channel bandwidth of 200 MHz, the network checks *channelBW-DL-IAB-r16*.  For FR1, the leading/leftmost bit in *channelBWs-DL-v1590* indicates 70MHz, the second leftmost bit indicates 45MHz, the third leftmost bit indicates 35MHz and all the remaining bits in *channelBWs-DL-v1590* shall be set to 0.  For RedCap UE, the maximum supported bandwidth in FR1 is 20Mhz, and the maximum supported bandwidth in FR2 is 100Mhz.  NOTE: To determine whether the UE supports a specific SCS for a given band, the network validates the *supportedSubCarrierSpacingDL* and the *scs-60kHz*. To determine whether the UE supports a channel bandwidth of 90 MHz, the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombinationSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-DL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthDL*. | Band | Yes | N/A | N/A |
| ***channelBWs-UL***  Indicates for each subcarrier spacing the UE supported channel bandwidths.  Absence of the *channelBWs-UL* (without suffix) for a band or absence of specific scs-XXkHz entry for a supported subcarrier spacing means that the UE supports the channel bandwidths among [5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100] and [50, 100, 200] that were defined in clause 5.3.5 of TS 38.101-1 version 15.7.0 [2] and TS 38.101-2 version 15.7.0 [3] for the given band or the specific SCS entry. For IAB-MT, to determine whether the IAB-MT supports a channel bandwidth of 100 MHz, the network checks *channelBW-UL-IAB-r16*.  For FR1, the bits in *channelBWs-UL* (without suffix) starting from the leading / leftmost bit indicate 5, 10, 15, 20, 25, 30, 40, 50, 60 and 80MHz. For FR2, the bits in *channelBWs-UL* (without suffix) starting from the leading / leftmost bit indicate 50, 100 and 200MHz. The third / rightmost bit (for 200MHz) shall be set to 1. For IAB-MT the third / rightmost bit (for 200MHz) is ignored. To determine whether the IAB-MT supports a channel bandwidth of 200 MHz, the network checks *channelBW-UL-IAB-r16*.  For FR1, the leading/leftmost bit in *channelBWs-UL-v1590* indicates 70 MHz, the second leftmost bit indicates 45MHz, the third leftmost bit indicates 35MHz and all the remaining bits in *channelBWs-UL-v1590* shall be set to 0.  NOTE: To determine whether the UE supports a specific SCS for a given band, the network validates the *supportedSubCarrierSpacingUL* and the *scs-60kHz*. To determine whether the UE supports a channel bandwidth of 90 MHz the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombiantionSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-UL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthUL*. | Band | Yes | N/A | N/A |
| ***channelBW-DL-IAB-r16***  Indicates whether the IAB-MT supports channel bandwidth of 100 MHz for a given SCS in FR1 for DL or whether the IAB-MT supports channel bandwidth of 200 MHz for a given SCS in FR2 for DL. | Band | No | N/A | N/A |
| ***channelBW-UL-IAB-r16***  Indicates whether the IAB-MT supports channel bandwidth of 100 MHz for a given SCS in FR1 for UL or whether the IAB-MT supports channel bandwidth of 200 MHz for a given SCS in FR2 for UL. | Band | No | N/A | N/A |

4.2.7.6 *FeatureSetDownlinkPerCC* parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***multiDCI-MultiTRP-r16***  Indicates whether the UE supports multi-DCI based multi-TRP and support of fully/partially overlapping PDSCHs in time and non-overlapping in frequency. This capability applies only to BWPs where two values of *coresetPoolIndex* are configured. The capability signalling contains the following:  - *maxNumberCORESET-r16* indicates maximum number of CORESETs configured per BWP per cell in addition to CORESET 0.  - *maxNumberCORESETPerPoolIndex-r16* indicates maximum number of CORESETs configured per *coresetPoolIndex* per BWP per cell in addition to CORESET 0.  - *maxNumberUnicastPDSCH-PerPool-r16* indicates maximum number of unicast PDSCHs per *coresetPoolIndex* per slot.  NOTE 1: A UE may assume that its maximum receive timing difference between the DL transmissions from two TRPs is within a Cyclic Prefix.  NOTE 2: Processing capability 2 is not supported in any CC if at least one CC is configured with two values of *coresetPoolIndex*.  NOTE 3: If UE reports value N1 for *maxNumberCORESET-r16*, that means UE supports up to min (N1+1, 5) CORESETs in total (including CORESET#0) if there is CORESET#0, and supports maximal N1 CORESETs if there is no CORESET#0.  NOTE 4: If UE reports value N2 for *maxNumberCORESETPerPoolIndex-r16*, that means UE supports up to min (N2+1, 3) CORESETs in total (including CORESET#0) for a TRP if there is CORESET#0, and supports maximal N2 CORESETs for another TRP if there is no CORESET#0. | FSPC | No | N/A | N/A |
| ***supportedBandwidthDL***  Indicates maximum DL channel bandwidth supported for a given SCS that UE supports within a single CC (and in case of intra-frequency DAPS handover for the source and target cells), which is defined in Table 5.3.5-1 in TS 38.101-1 [2] for FR1 and Table 5.3.5-1 in TS 38.101-2 [3] for FR2.  For FR1, all the bandwidths listed in TS38.101-1 Table 5.3.5-1 for each band shall be mandatory with a single CC unless indicated optional. For FR2, the set of mandatory CBW is 50, 100, 200 MHz. When this field is included in a band combination with a single band entry and a single CC entry (i.e. non-CA band combination), the UE shall indicate the maximum channel bandwidth for the band according to TS 38.101-1 [2] and TS 38.101-2 [3].  For RedCap UE, the maximum supported bandwidth in FR1 is 20Mhz, and the maximum supported bandwidth in FR2 is 100Mhz.  NOTE: To determine whether the UE supports a channel bandwidth of 90 MHz, the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombinationSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-DL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthDL*. | FSPC | CY | N/A | N/A |
| ***supportedModulationOrderDL***  Indicates the maximum supported modulation order to be applied for downlink in the carrier in the max data rate calculation as defined in 4.1.2. If included, the network may use a modulation order on this serving cell which is higher than the value indicated in this field as long as UE supports the modulation of higher value for downlink. If not included:  - for FR1, the network uses the modulation order signalled in *pdsch-256QAM-FR1*.  - for FR2, the network uses the modulation order signalled per band i.e. *pdsch-256QAM-FR2* if signalled. If not signalled in a given band, the network shall use the modulation order 64QAM.  In all the cases, it shall be ensured that the data rate does not exceed the max data rate (*DataRate*) and max data rate per CC (*DataRateCC*) according to TS 38.214 [12]. | FSPC | No | N/A | N/A |

Companies are invited to provide your view on the TP for maximum bandwidth shown as above. Also please indicate if anything is missing. Companies that do not agree the TP should provide the alternative TP or suggested change.

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Intel | Agree |  |
| ZTE, Sanechips | See comment | Our interpretation of the WID is:   1. The maximum bandwidth supported is 20MHz for FR1; 100MHz for FR2. And it is mandatorily supported for RedCap UEs. The UE is not allowed to report larger values, but the UE is allowed to indicate the support of smaller values (e.g. 5MHz, 10MHz). 2. The maximum bandwidth includes both DL and UL capabilities.   So regarding the spec change, we suggest to update the field description into (similar change can be applied to **channelBWs-UL**):   |  | | --- | | For FR1, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 5, 10, 15, 20, 25, 30, 40, 50, 60 and 80MHz. For FR2, the bits in *channelBWs-DL* (without suffix) starting from the leading / leftmost bit indicate 50, 100 and 200MHz. The third / rightmost bit (for 200MHz) shall be set to 1. For IAB-MT the third / rightmost bit (for 200MHz) is ignored. To determine whether the IAB-MT supports a channel bandwidth of 200 MHz, the network checks *channelBW-DL-IAB-r16*. For FR1 RedCap UE, the bit indicates 20MHz shall be set to 1, and the bits indicate 25, 30, 40, 50, 60 and 80MHz are not applicable (set to 0). For FR2 RedCap UE, the bit indicates 100MHz shall be set to 1, and the bit indicates 200MHz is not applicable (set to 0).  For FR1, the leading/leftmost bit in *channelBWs-DL-v1590* indicates 70MHz, the second leftmost bit indicates 45MHz, the third leftmost bit indicates 35MHz and all the remaining bits in *channelBWs-DL-v1590* shall be set to 0. *channelBWs-DL-v1590* is not applicable to RedCap UE. |   In addition, a clarification sentence can be added in the field description of *channelBW-90mhz*. Like:  “This capability is not applicable to RedCap UE.” |
| Apple | We are ok with Intel’s suggested change. |  |
| Huawei, HiSilicon | See comments | 1. On the wording, we prefer the manner from ZTE (e.g. clarify larger bandwidth is not supported.) 2. No sure if the change to *supportedBandwidthDL* is really needed. 3. We prefer to capture those in a **new section for RedCap**, to avoid any confusion/conflict with the description for non-RedCap UE.   **Section 4.2.xx**   |  |  |  | | --- | --- | --- | | |  | | --- | | **Definitions for parameters** | | ***channelBWs-DL***  Indicates for each subcarrier spacing the UE supported channel bandwidths for RedCap UE.  For FR1, the bit indicates 20MHz shall be set to 1, and the bits indicate 25, 30, 40, 50, 60 and 80MHz are not applicable (set to 0). For FR2 RedCap UE, the bit indicates 100MHz shall be set to 1, and the bit indicates 200MHz is not applicable (set to 0). | | |
| OPPO | We are ok with ZTE’s suggested change. |  |
| Spreadtrum | Prefer the version from ZTE. | The similar modification are also needed for **channelBWs-UL,** which is missed. |
| Qualcomm | Disagree | In our view, no capability signaling for RedCap’s maximum UE bandwidth (20MHz for FR1 and 100MHz for FR2) is needed because it is a mandatory feature for all RedCap UEs. There are no other possible values.  Our preference is to create a new section in 38.306 which specifies all aspects that defines RedCap UEs. RedCap UEs’ maximum UE bandwidth should be captured in that new section, instead of in the field description of non-RedCap UE’s channel BWs. |
| Futurewei | No | Agree with Qualcomm’s comment. This capability can be captured under ***redCap-r17***, which is being discussed under Q 3.2.5. |

### Phase 2-Discussion point 3.2: How to capture number of Rx branches;

According to the WID [5], the minimum number of Rx branches for RedCap UE is 1 Rx.

* + *Reduced minimum number of Rx branches:*
    - *For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.*
    - *For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx* *branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.*
    - *A means shall be specified by which the Gnb can know the number of Rx branches of the UE.*

So far, there is no explicit capability signalling on the number of Rx branches since it is frequency specific, e.g. 2 for some frequencies and 4 for other frequencies. For RedCap UE, 1Rx is mandatory and 2Rx is optional. The network has no idea whether 2Rx is supported even if the network can identify it is RedCap UE. Therefore capability signalling on the supported Rx number is needed.

**Phase 2-Discussion point 3.2-1: Do you agree the need to introduce capability signalling on the supported Rx number for RedCap UE?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Yes/No** | **Comments, if any** |
| Intel | Yes |  |
| ZTE, Sanechips | No | RAN1 has made following agreement:   |  | | --- | | Agreement:  For UE capability signalling, the number of Rx branches for RedCap is implicitly indicated by the corresponding capability parameter *maxNumberMIMO-LayersPDSCH* in the existing UE capability framework.   * Detailed signalling is up to RAN2 |   So we think there is no need to introduce separate capability to indicate the supported Rx number for RedCap UE. |
| Apple | No | Same view as ZTE. |
| Huawie, HiSilicon | No | Agree with ZTE. |
| OPPO | No | Agree with ZTE and thank ZTE for pointing this out. |
| Spreadtrum | No | Agree with ZTE. |
| Qualcomm | No | Agree with ZTE |
| Sierra Wireless | No | We can use the MIMO layer capability parameter as mentioned by ZTE |
| Futurewei | No | Agree with ZTE. |

**Phase 2-Discussion point 3.2-2: If answer to 3.2-1 is yes, where should it be put?**

* **Option 1:** per UE, i.e. RF-Parameters;
* **Option 2:** per band, i.e. BandNR;
* **Option 3:** others?

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, 2 or?** | **Comments, if any** |
| Intel | Option 2 |  |
| ZTE, Sanechips |  | We think new capability is not needed. |
|  |  |  |

#### TS38.331 TP on minimum number of Rx branches-Option1 and option 2

***RF-Parameters* information element**

-- ASN1START

-- TAG-RF-PARAMETERS-START

RF-Parameters ::= SEQUENCE {

supportedBandListNR SEQUENCE (SIZE (1..maxBands)) OF BandNR,

supportedBandCombinationList BandCombinationList OPTIONAL,

appliedFreqBandListFilter FreqBandList OPTIONAL,

...,

[[

supportedBandCombinationList-v1540 BandCombinationList-v1540 OPTIONAL,

srs-SwitchingTimeRequested ENUMERATED {true} OPTIONAL

]],

[[

supportedBandCombinationList-v1550 BandCombinationList-v1550 OPTIONAL

]],

[[

supportedBandCombinationList-v1560 BandCombinationList-v1560 OPTIONAL

]],

[[

supportedBandCombinationList-v1610 BandCombinationList-v1610 OPTIONAL,

supportedBandCombinationListSidelinkEUTRA-NR-r16 BandCombinationListSidelinkEUTRA-NR-r16 OPTIONAL,

supportedBandCombinationList-UplinkTxSwitch-r16 BandCombinationList-UplinkTxSwitch-r16 OPTIONAL

]],

[[

supportedBandCombinationList-v1630 BandCombinationList-v1630 OPTIONAL,

supportedBandCombinationListSidelinkEUTRA-NR-v1630 BandCombinationListSidelinkEUTRA-NR-v1630 OPTIONAL,

supportedBandCombinationList-UplinkTxSwitch-v1630 BandCombinationList-UplinkTxSwitch-v1630 OPTIONAL

]],

[[

supportedBandCombinationList-v1640 BandCombinationList-v1640 OPTIONAL,

supportedBandCombinationList-UplinkTxSwitch-v1640 BandCombinationList-UplinkTxSwitch-v1640 OPTIONAL

]],

[[

minimumNumberOfRx-r17 ENUMERATED {n1, n2} OPTIONAL

]]

}

BandNR ::= SEQUENCE {

bandNR FreqBandIndicatorNR,

modifiedMPR-Behaviour BIT STRING (SIZE (8)) OPTIONAL,

mimo-ParametersPerBand MIMO-ParametersPerBand OPTIONAL,

extendedCP ENUMERATED {supported} OPTIONAL,

multipleTCI ENUMERATED {supported} OPTIONAL,

bwp-WithoutRestriction ENUMERATED {supported} OPTIONAL,

bwp-SameNumerology ENUMERATED {upto2, upto4} OPTIONAL,

bwp-DiffNumerology ENUMERATED {upto4} OPTIONAL,

crossCarrierScheduling-SameSCS ENUMERATED {supported} OPTIONAL,

pdsch-256QAM-FR2 ENUMERATED {supported} OPTIONAL,

pusch-256QAM ENUMERATED {supported} OPTIONAL,

ue-PowerClass ENUMERATED {pc1, pc2, pc3, pc4} OPTIONAL,

rateMatchingLTE-CRS ENUMERATED {supported} OPTIONAL,

channelBWs-DL CHOICE {

fr1 SEQUENCE {

scs-15kHz BIT STRING (SIZE (10)) OPTIONAL,

scs-30kHz BIT STRING (SIZE (10)) OPTIONAL,

scs-60kHz BIT STRING (SIZE (10)) OPTIONAL

},

fr2 SEQUENCE {

scs-60kHz BIT STRING (SIZE (3)) OPTIONAL,

scs-120kHz BIT STRING (SIZE (3)) OPTIONAL

}

} OPTIONAL,

channelBWs-UL CHOICE {

fr1 SEQUENCE {

scs-15kHz BIT STRING (SIZE (10)) OPTIONAL,

scs-30kHz BIT STRING (SIZE (10)) OPTIONAL,

scs-60kHz BIT STRING (SIZE (10)) OPTIONAL

},

fr2 SEQUENCE {

scs-60kHz BIT STRING (SIZE (3)) OPTIONAL,

scs-120kHz BIT STRING (SIZE (3)) OPTIONAL

}

} OPTIONAL,

...,

[[

maxUplinkDutyCycle-PC2-FR1 ENUMERATED {n60, n70, n80, n90, n100} OPTIONAL

]],

[[

pucch-SpatialRelInfoMAC-CE ENUMERATED {supported} OPTIONAL,

powerBoosting-pi2BPSK ENUMERATED {supported} OPTIONAL

]],

[[

maxUplinkDutyCycle-FR2 ENUMERATED {n15, n20, n25, n30, n40, n50, n60, n70, n80, n90, n100} OPTIONAL

]],

[[

channelBWs-DL-v1590 CHOICE {

fr1 SEQUENCE {

scs-15kHz BIT STRING (SIZE (16)) OPTIONAL,

scs-30kHz BIT STRING (SIZE (16)) OPTIONAL,

scs-60kHz BIT STRING (SIZE (16)) OPTIONAL

},

fr2 SEQUENCE {

scs-60kHz BIT STRING (SIZE (8)) OPTIONAL,

scs-120kHz BIT STRING (SIZE (8)) OPTIONAL

}

} OPTIONAL,

channelBWs-UL-v1590 CHOICE {

fr1 SEQUENCE {

scs-15kHz BIT STRING (SIZE (16)) OPTIONAL,

scs-30kHz BIT STRING (SIZE (16)) OPTIONAL,

scs-60kHz BIT STRING (SIZE (16)) OPTIONAL

},

fr2 SEQUENCE {

scs-60kHz BIT STRING (SIZE (8)) OPTIONAL,

scs-120kHz BIT STRING (SIZE (8)) OPTIONAL

}

} OPTIONAL

]],

[[

asymmetricBandwidthCombinationSet BIT STRING (SIZE (1..32)) OPTIONAL

]],

[[

-- R1 10: NR-unlicensed

sharedSpectrumChAccessParamsPerBand-r16 SharedSpectrumChAccessParamsPerBand-r16 OPTIONAL,

-- R1 11-7b: Independent cancellation of the overlapping PUSCHs in an intra-band UL CA

cancelOverlappingPUSCH-r16 ENUMERATED {supported} OPTIONAL,

-- R1 14-1: Multiple LTE-CRS rate matching patterns

multipleRateMatchingEUTRA-CRS-r16 SEQUENCE {

maxNumberPatterns-r16 INTEGER (2..6),

maxNumberNon-OverlapPatterns-r16 INTEGER (1..3)

} OPTIONAL,

-- R1 14-1a: Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier

overlapRateMatchingEUTRA-CRS-r16 ENUMERATED {supported} OPTIONAL,

-- R1 14-2: PDSCH Type B mapping of length 9 and 10 OFDM symbols

pdsch-MappingTypeB-Alt-r16 ENUMERATED {supported} OPTIONAL,

-- R1 14-3: One slot periodic TRS configuration for FR1

oneSlotPeriodicTRS-r16 ENUMERATED {supported} OPTIONAL,

olpc-SRS-Pos-r16 OLPC-SRS-Pos-r16 OPTIONAL,

spatialRelationsSRS-Pos-r16 SpatialRelationsSRS-Pos-r16 OPTIONAL,

simulSRS-MIMO-TransWithinBand-r16 ENUMERATED {n2} OPTIONAL,

channelBW-DL-IAB-r16 CHOICE {

fr1-100mhz SEQUENCE {

scs-15kHz ENUMERATED {supported} OPTIONAL,

scs-30kHz ENUMERATED {supported} OPTIONAL,

scs-60kHz ENUMERATED {supported} OPTIONAL

},

fr2-200mhz SEQUENCE {

scs-60kHz ENUMERATED {supported} OPTIONAL,

scs-120kHz ENUMERATED {supported} OPTIONAL

}

} OPTIONAL,

channelBW-UL-IAB-r16 CHOICE {

fr1-100mhz SEQUENCE {

scs-15kHz ENUMERATED {supported} OPTIONAL,

scs-30kHz ENUMERATED {supported} OPTIONAL,

scs-60kHz ENUMERATED {supported} OPTIONAL

},

fr2-200mhz SEQUENCE {

scs-60kHz ENUMERATED {supported} OPTIONAL,

scs-120kHz ENUMERATED {supported} OPTIONAL

}

} OPTIONAL,

rasterShift7dot5-IAB-r16 ENUMERATED {supported} OPTIONAL,

ue-PowerClass-v1610 ENUMERATED {pc1dot5} OPTIONAL,

condHandover-r16 ENUMERATED {supported} OPTIONAL,

condHandoverFailure-r16 ENUMERATED {supported} OPTIONAL,

condHandoverTwoTriggerEvents-r16 ENUMERATED {supported} OPTIONAL,

condPSCellChange-r16 ENUMERATED {supported} OPTIONAL,

condPSCellChangeTwoTriggerEvents-r16 ENUMERATED {supported} OPTIONAL,

mpr-PowerBoost-FR2-r16 ENUMERATED {supported} OPTIONAL,

-- R1 11-9: Multiple active configured grant configurations for a BWP of a serving cell

activeConfiguredGrant-r16 SEQUENCE {

maxNumberConfigsPerBWP-r16 ENUMERATED {n1, n2, n4, n8, n12},

maxNumberConfigsAllCC-r16 INTEGER (2..32)

} OPTIONAL,

-- R1 11-9a: Joint release in a DCI for two or more configured grant Type 2 configurations for a given BWP of a serving cell

jointReleaseConfiguredGrantType2-r16 ENUMERATED {supported} OPTIONAL,

-- R1 12-2: Multiple SPS configurations

sps-r16 SEQUENCE {

maxNumberConfigsPerBWP-r16 INTEGER (1..8),

maxNumberConfigsAllCC-r16 INTEGER (2..32)

} OPTIONAL,

-- R1 12-2a: Joint release in a DCI for two or more SPS configurations for a given BWP of a serving cell

jointReleaseSPS-r16 ENUMERATED {supported} OPTIONAL,

-- R1 13-19: Simultaneous positioning SRS and MIMO SRS transmission within a band across multiple CCs

simulSRS-TransWithinBand-r16 ENUMERATED {n2} OPTIONAL,

trs-AdditionalBandwidth-r16 ENUMERATED {trs-AddBW-Set1, trs-AddBW-Set2} OPTIONAL,

handoverIntraF-IAB-r16 ENUMERATED {supported} OPTIONAL

]],

[[

-- R1 22-5a: Simultaneous transmission of SRS for antenna switching and SRS for CB/NCB /BM for intra-band UL CA

-- R1 22-5c: Simultaneous transmission of SRS for antenna switching and SRS for antenna switching for intra-band UL CA

simulTX-SRS-AntSwitchingIntraBandUL-CA-r16 SimulSRS-ForAntennaSwitching-r16 OPTIONAL,

-- R1 10: NR-unlicensed

sharedSpectrumChAccessParamsPerBand-v1630 SharedSpectrumChAccessParamsPerBand-v1630 OPTIONAL

]],

[[

handoverUTRA-FDD-r16 ENUMERATED {supported} OPTIONAL,

-- R4 7-4: Report the shorter transient capability supported by the UE: 2, 4 or 7us

enhancedUL-TransientPeriod-r16 ENUMERATED {us2, us4, us7} OPTIONAL,

sharedSpectrumChAccessParamsPerBand-v1640 SharedSpectrumChAccessParamsPerBand-v1640 OPTIONAL

]],

[[

minimumNumberOfRx-r17 ENUMERATED {n1, n2} OPTIONAL

]]

}

-- TAG-RF-PARAMETERS-STOP

-- ASN1STOP

|  |
| --- |
| ***RF-Parameters* field descriptions** |
| ***appliedFreqBandListFilter***  In this field the UE mirrors the *FreqBandList* that the NW provided in the capability enquiry, if any. The UE filtered the band combinations in the *supportedBandCombinationList* in accordance with this *appliedFreqBandListFilter*. The UE does not include this field if the UE capability is requested by E-UTRAN and the network request includes the field *eutra-nr-only* [10]. |
| ***supportedBandCombinationList***  A list of band combinations that the UE supports for NR (and NR-DC, if requested). The *FeatureSetCombinationId*:s in this list refer to the *FeatureSetCombination* entries in the *featureSetCombinations* list in the *UE-NR-Capability* IE. The UE does not include this field if the UE capability is requested by E-UTRAN and the network request includes the field *eutra-nr-only* [10]. |
| ***supportedBandCombinationListSidelinkEUTRA-NR***  A list of band combinations that the UE supports for NR sidelink communication only, for joint NR sidelink communication and V2X sidelink communication, or for V2X sidelink communication only. The UE does not include this field if the UE capability is requested by E-UTRAN (see TS 36.331[10]) and the network request includes the field *eutra-nr-only*. |
| ***supportedBandCombinationList-UplinkTxSwitch***  A list of band combinations that the UE supports dynamic uplink Tx switching for NR UL CA and SUL. The *FeatureSetCombinationId*:s in this list refer to the *FeatureSetCombination* entries in the *featureSetCombinations* list in the *UE-NR-Capability* IE. The UE does not include this field if the UE capability is requested by E-UTRAN and the network request includes the field *eutra-nr-only* [10]. |

#### TS38.306 TP on minimum number of Rx branches-Option1

4.2.7.11 Other PHY parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***appliedFreqBandListFilter***  Mirrors the *FreqBandList* that the NW provided in the capability enquiry, if any. The UE filtered the band combinations in the *supportedBandCombinationList* in accordance with this *appliedFreqBandListFilter*. | UE | No | No | No |
| ***downlinkSetEUTRA***  Indicates the features that the UE supports on the DL carriers corresponding to one EUTRA band entry in a band combination by FeatureSetEUTRA-DownlinkId. The FeatureSetEUTRA-DownlinkId = 0 means that the UE does not support a EUTRA DL carrier in this band of a band combination. | Band | N/A | N/A | N/A |
| ***downlinkSetNR***  Indicates the features that the UE supports on the DL carriers corresponding to one NR band entry in a band combination by FeatureSetDownlinkId. The FeatureSetDownlinkId = 0 means that the UE does not support a DL carrier in this band of a band combination. A fallback per band feature set resulting from the reported DL feature set that has fallback per CC feature set is not signalled but the UE shall support it. | Band | N/A | N/A | N/A |
| ***featureSetCombinations***  Pools of feature sets that the UE supports on the NR or MR-DC band combinations. | UE | N/A | No | No |
| ***featureSets***  Pools of downlink and uplink features sets as well as a pool of FeatureSetCombination elements. A FeatureSetCombination refers to the IDs of the feature set(s) that the UE supports in that FeatureSetCombination. The BandCombination entries in the BandCombinationList then indicate the ID of the FeatureSetCombination that the UE supports for that band combination. | UE | N/A | No | No |
| ***minimumNumberOfRx-r17***  Indicates the minimum number of Rx branches that the RedCap UE supports. Value n1 corresponds to 1Rx, value n2 corresponds to 2Rx. 1Rx is mandatory for RedCap UE. | UE | No | N/A | N/A |
| ***naics-Capability-List***  Indicates that UE in MR-DC supports NAICS as defined in TS 36.331 [17]. | UE | No | No | No |

#### TS38.306 TP on minimum number of Rx branches-Option2

/\*\*\* omitted unrelated parts\*\*\*/

4.2.7.2 *BandNR parameters*

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***maxUplinkDutyCycle-FR2***  Indicates the maximum percentage of symbols during 1s that can be scheduled for uplink transmission at the UE maximum transmission power, so as to ensure compliance with applicable electromagnetic power density exposure requirements provided by regulatory bodies. This field is applicable for all power classes UE in FR2 as specified in TS 38.101-2 [3]. Value n15 corresponds to 15%, value n20 corresponds to 20% and so on. If the field is absent or the percentage of uplink symbols transmitted within any 1s evaluation period is larger than *maxUplinkDutyCycle-FR2*, the UE behaviour is specified in TS 38.101-2 [3]. This capability is not applicable to IAB-MT. | Band | No | N/A | FR2 only |
| ***minimumNumberOfRx-r17***  Indicates the minimum number of Rx branches that the RedCap UE supports. Value n1 corresponds to 1Rx, value n2 corresponds to 2Rx. 1Rx is mandatory for RedCap UE. | Band | No | N/A | N/A |
| ***modifiedMPR-Behaviour***  Indicates whether UE supports modified MPR behaviour defined in TS 38.101-1 [2] and TS 38.101-2 [3]. | Band | No | N/A | N/A |

Companies are invited to provide your view on the TP for minimum number of Rx branches shown as above (Option 1 and option 2). Also please indicate if anything is missing. Companies that do not agree should provide the alternative TP or suggested change.

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Intel | Agree |  |
| ZTE, Sanechips |  | We think new capability is not needed. |
|  |  |  |

### Phase 2-Discussion point 3.3: How to capture MIMO layer;

According to the WID [5]:

* + *Maximum number of DL MIMO layers:*
    - *For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.*
    - *For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported.*

Note: the MIMO layer is reflected by minimum number of Rx branches;

To capture the restriction on maximum number of DL MIMO layer for RedCap UE, the field description of *maxNumberMIMO-LayersPDSCH* should be updated;

#### TS38.306 TP on Maximum number of DL MIMO layer:

4.2.7.6 *FeatureSetDownlinkPerCC* parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***multiDCI-MultiTRP-r16***  Indicates whether the UE supports multi-DCI based multi-TRP and support of fully/partially overlapping PDSCHs in time and non-overlapping in frequency. This capability applies only to BWPs where two values of *coresetPoolIndex* are configured. The capability signalling contains the following:  - *maxNumberCORESET-r16* indicates maximum number of CORESETs configured per BWP per cell in addition to CORESET 0.  - *maxNumberCORESETPerPoolIndex-r16* indicates maximum number of CORESETs configured per *coresetPoolIndex* per BWP per cell in addition to CORESET 0.  - *maxNumberUnicastPDSCH-PerPool-r16* indicates maximum number of unicast PDSCHs per *coresetPoolIndex* per slot.  NOTE 1: A UE may assume that its maximum receive timing difference between the DL transmissions from two TRPs is within a Cyclic Prefix.  NOTE 2: Processing capability 2 is not supported in any CC if at least one CC is configured with two values of *coresetPoolIndex*.  NOTE 3: If UE reports value N1 for *maxNumberCORESET-r16*, that means UE supports up to min (N1+1, 5) CORESETs in total (including CORESET#0) if there is CORESET#0, and supports maximal N1 CORESETs if there is no CORESET#0.  NOTE 4: If UE reports value N2 for *maxNumberCORESETPerPoolIndex-r16*, that means UE supports up to min (N2+1, 3) CORESETs in total (including CORESET#0) for a TRP if there is CORESET#0, and supports maximal N2 CORESETs for another TRP if there is no CORESET#0. | FSPC | No | N/A | N/A |
| ***supportedBandwidthDL***  Indicates maximum DL channel bandwidth supported for a given SCS that UE supports within a single CC (and in case of intra-frequency DAPS handover for the source and target cells), which is defined in Table 5.3.5-1 in TS 38.101-1 [2] for FR1 and Table 5.3.5-1 in TS 38.101-2 [3] for FR2.  For FR1, all the bandwidths listed in TS38.101-1 Table 5.3.5-1 for each band shall be mandatory with a single CC unless indicated optional. For FR2, the set of mandatory CBW is 50, 100, 200 MHz. When this field is included in a band combination with a single band entry and a single CC entry (i.e. non-CA band combination), the UE shall indicate the maximum channel bandwidth for the band according to TS 38.101-1 [2] and TS 38.101-2 [3].  For RedCap UE, the maximum supported bandwidth in FR1 is 20Mhz, and the maximum supported bandwidth in FR2 is 100Mhz.  NOTE: To determine whether the UE supports a channel bandwidth of 90 MHz, the network may ignore this capability and validate instead the *channelBW-90mhz* and the *supportedBandwidthCombinationSet*. For serving cell(s) with other channel bandwidths the network validates the *channelBWs-DL*, the *supportedBandwidthCombinationSet*, the *supportedBandwidthCombinationSetIntraENDC*, the *asymmetricBandwidthCombinationSet* (for a band supporting asymmetric channel bandwidth as defined in clause 5.3.6 of TS 38.101-1 [2]) and *supportedBandwidthDL*. | FSPC | CY | N/A | N/A |
| ***supportedModulationOrderDL***  Indicates the maximum supported modulation order to be applied for downlink in the carrier in the max data rate calculation as defined in 4.1.2. If included, the network may use a modulation order on this serving cell which is higher than the value indicated in this field as long as UE supports the modulation of higher value for downlink. If not included:  - for FR1, the network uses the modulation order signalled in *pdsch-256QAM-FR1*.  - for FR2, the network uses the modulation order signalled per band i.e. *pdsch-256QAM-FR2* if signalled. If not signalled in a given band, the network shall use the modulation order 64QAM.  In all the cases, it shall be ensured that the data rate does not exceed the max data rate (*DataRate*) and max data rate per CC (*DataRateCC*) according to TS 38.214 [12]. | FSPC | No | N/A | N/A |

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***channelBW-90mhz***  Indicates whether the UE supports the channel bandwidth of 90 MHz.  For FR1, the UE shall indicate support according to TS 38.101-1 [2], Table 5.3.5-1. | FSPC | CY | N/A | FR1 only |
| ***maxNumberMIMO-LayersPDSCH***  Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception. For single CC standalone NR, it is mandatory with capability signaling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. If absent, the UE does not support MIMO on this carrier.  RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported. | FSPC | CY | N/A | N/A |

Companies are invited to provide your view on the TP for maximum number of DL MIMO layer shown as above. Also please indicate if anything is missing. Companies that do not agree should provide the alternative TP or suggested change.

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Intel | Agree |  |
| ZTE, Sanechips | See comments | For DL MIMO:  For 1 Rx RedCap UE, DL MIMO is not supported, this can be indicated via the **absence** of *maxNumberMIMO-LayersPDSCH* (already covered by the last sentence of field description: “If absent, the UE does not support MIMO on this carrier.”).  For 2 Rx RedCap UE, the UE can only report “twoLayers” for *maxNumberMIMO-LayersPDSCH*, so “fourLayers, eightLayers” values are not applicable to RedCap UEs.  We suggest to change the sentence into:   |  | | --- | | ***maxNumberMIMO-LayersPDSCH***  Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception. For single CC standalone NR, it is mandatory with capability signaling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. For RedCap UE, if signalled, only 2 MIMO layers can be reported. If absent, the UE does not support MIMO on this carrier. |   For UL MIMO:   * + - 1. RedCap UE only supports 1 Tx transmission, so uplink MIMO is not supported. In this case, for uplink MIMO capabilities (see below), we need to clarify in the field description that “This capability is not applicable to RedCap UE.”  1. *maxNumberMIMO-LayersCB-PUSCH* 2. *maxNumberMIMO-LayersNonCB-PUSCH* |
| Apple | Prefer ZTE’s version. |  |
| Huawei, HiSilicon | See comments | Fine with the wording from rapporteur. But prefer to use a new section for RedCap specific capability. Maybe we can wait for R1 on the UL MIMO.  **Section 4.2.xx**   |  |  |  | | --- | --- | --- | | |  | | --- | | **Definitions for parameters** | | ***maxNumberMIMO-LayersPDSCH***  Defines the maximum number of spatial multiplexing layer(s) supported by the RedCap UE for DL reception.  RedCap UE supports 1 DL MIMO layer if 1 Rx branch is supported, and 2 DL MIMO layers if 2 Rx branches are supported. | | |
| OPPO | Prefer ZTE’s suggested changes |  |
| Spreadtrum | Prefer ZTE’s version. |  |
| Qualcomm | - | Our preference is to include the aspects related to DL MIMO layers in the new section in 38.306 which specifies all aspects that defines RedCap UEs. If this is not agreeable, we are fine with the TP from ZTE. |
| Sierra Wireless | Prefer ZTE’s version |  |
| Futurewei | Agree | In ZTE’s version, first, the last sentence (“If absent, …”) implies that the UE supports 1 Rx antenna branch if the UE is a RedCap UE. However, such implication doesn’t apply to a non-RedCap UE. Not sure that aspect is made very clear by reusing the legacy text without making any change to it. Secondly, we will mix the RedCap UE and non-RedCap UE in the mid of the description and with some legacy text applying to both, which style is quite different from the style that we use for other parameters.  For those reasons, we prefer rapporteur’s version (or at least we should keep the descriptions for non-RedCap and RedCap separated). |

### Phase 2-Discussion point 3.4: How to capture maximum modulation order;

According to the WID [5]:

* + *Relaxed maximum modulation order:*
    - *Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.*
    - *No other relaxations of maximum modulation order are specified for a RedCap UE.*

To capture the restriction on maximum number of DL MIMO layer for RedCap UE, the field description of *pdsch-256QAM-FR1* should be updated;

#### TS38.306 TP on Maximum number of 256QAM

4.2.7.10 *Phy-Parameters*

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***pdsch-256QAM-FR1***  Indicates whether the UE supports 256QAM modulation scheme for PDSCH for FR1 as defined in 7.3.1.2 of TS 38.211 [6].  It is optional for RedCap UE. | UE | Yes | No | FR1 only |

Companies are invited to provide your view on the TP for maximum DL modulation order shown as above. Also please indicate if anything is missing.

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Intel | Agree |  |
| ZTE, Sanechips | See comment | With addition, the value for column “M” should be changed from “Yes” into “CY”.  In addition, we suggest to change the new sentence into:  “It is mandatory with capability signaling for non-RedCap UE and optional for RedCap UE.” |
| Apple | Agree with ZTE on CY |  |
| Huawei, HiSilicon | See comment | Agree the column M should be clarified.  We don’t need to add the “It is optional for RedCap UE.”  But we prefer to use a **new section** for this.  **Section 4.2.xx**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** | | ***pdsch-256QAM-FR1***  Indicates whether the RedCap UE supports 256QAM modulation scheme for PDSCH for FR1 as defined in 7.3.1.2 of TS 38.211 [6]. | UE | No | No | FR1 only | |
| OPPO | Agree with ZTE on CY |  |
| Spreadtrum | Agree with ZTE |  |
| Qualcomm | Agree with ZTE |  |
| Sierra Wireless | Agree with ZTE on CY |  |
| Futurewei | Agree with the changes suggested by ZTE |  |

### Phase 2-Discussion point 3.5: How to capture CA, DC;

According to the WID [5], CA and DC are not supported for RedCap UE;

* + *Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths. [RAN2, RAN1]*

There are lots of parameters related to CA, DC and MR-DC. For instance, the parameters under BandCombinationList, BandNR parameters, CA-ParametersEUTRA, CA-ParametersNR, FeatureSetDownlink parameters, FeatureSetDownlinkPerCC parameters, FeatureSetUplink parameters, FeatureSetUplinkPerCC parameters, MRDC-Parameters, Phy-Parameters, Other PHY parameters, NRDC-Parameters, CarrierAggregationVariant, MeasAndMobParameters, Inter-RAT parameters. To clarify CA, DC, etc features are not supported by RedCap UE, there are two options:

* **Option 1**: Find all CA, DC related fields, and add the clarification for each of them;
* **Option 2**: Add the clarification (CA, DC is not supported for RedCap UE) in general part, e.g. RedCap specific section;

**Phase 2-Discussion point 3.5: Companies are invited to provide your view on which option is preferred?**

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Option 1, option 2?** | **Comments, if any** |
| Intel | Option 2 | It is impossible to add the restriction for each CA/DC related fields. Rapporteur would prefer to create a new section to capture the restriction for RedCap UE, see changes in 3.2.6. |
| ZTE, Sanechips | Option 2 | Option 1 is clear, but it requires more specification effort. So we are fine to clarify it in general part. |
| Apple | Option 2 |  |
| Huawei, HiSilicon | Option 2 |  |
| OPPO | Option 2 |  |
| Spreadtrum | Option 2 |  |
| Qualcomm | Option 2 | We think Option 1 is rather error-prone, since there are many CA/DC related capabilities.  We think that exclusion of CA/DC can be specified in the new section that specifies all the definitions of RedCap (which we’ve suggested in our comment on DP 3.1). |
| Sierra Wireless | Option 2 |  |
| Futurewei | Option 2 |  |

#### TS38.306 TP on CA, DC – Option 2

4.2.xx RedCap parameters

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD**  **DIFF** | **FR1-FR2**  **DIFF** |
| --- | --- | --- | --- | --- |
| ***redCap-r17***  Indicates whether the UE is RedCap UE. The features CA, DC, NE-DC, (NG)-EN-DC are not supported for RedCap UE. | UE | No | N/A | N/A |

Companies are invited to provide your view on the TP for CA/DC shown as above. Also please indicate if anything is missing. Companies that do not agree should provide the alternative TP or suggested change.

|  |  |  |
| --- | --- | --- |
| **Company’s name** | **Agree or not** | **Comments, if any** |
| Intel | Agree |  |
| ZTE, Sanechips | Agree with comments | Suggest to change the second sentence into:  “All UE capabilities related to CA and MR-DC are not applicable for RedCap UE.” |
| Apple | Agree, but | We think the field definition (and also where it would be) can be decided in stage 3. We agree with spirit of this change. |
| Huawei, HiSilicon | See comments | We prefer to have one sub-clause to capture those capability not applicable to RedCap in this section (e.g. 4.2.xx.y). It is more readable if we capture those clarifications in separate paragraphs, rather than mixed in the box. |
| OPPO |  | Similar views with Huuawei. We prefer to capture these using separate paragraph, instead of adding a new parameter which is not visible in capability signaling. |
| Spreadtrum | Agree |  |
| Qualcomm | See comment | We think the 2nd sentence, i.e. definition of RedCap, should be specified in more details in a separate text (e.g. in the new section in 38.306 that defines RedCap), because there are more aspects in the definition of RedCap than not supporting CA/DC. If needed, a reference to that text can be included in the field description of this RedCap indicator. |
| Sierra Wireless | Agree with comments | Agree with the CA/DC text but if the generic name redCap-R17 is used, then additional text to specify other aspects of RedCap such as reduced bandwidth, default 64QAM, etc. should be added. |
| Futurewei | Agree with comments | Agree with companies that the second sentence should be moved to start a new paragraph and should include description of capabilities that are unique to RedCap UE (such as related to bandwidth) or generally not applicable to RedCap UE (such as CA/DC). |

### Phase 2-Discussion point 3.6: How to capture HD-FDD type A

According to the WID [5];for Duplex operation:

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

Rapporteur would suggest to postpone the discussion on this considering it is tightly related to RAN1 discussion. We can discuss the details once RAN1 has further progress on this.

# Summary report and proposals

<Section to be updated by Rapporteur>

This report summarizes the views of xx companies ().

Aiming to help with the meeting discussion/progress, the proposals are categorized starting with:

* [To agree] when there is large support and hence proposed for easy agreement.
* [To discuss] when there is substantial level of support and agreement may be possible.
* [FFS] when there is low support or companies propose new solutions or options to possibly consider further e.g. if there is sufficient support (understanding that these topic have not been discussed by all companies when providing their views in the different discussion points).

The proposals also start with a number: for the format [x], ‘x’ represents the number of supportive companies (i.e. these solutions are marked as FFS as the proposed solutions were not discussed by all companies) and, for the format [x/y], ‘x’ represents the number of supportive companies, and (y-x) the number of companies with different view.

1. **[To agree]** xxx
2. **[To discuss]** xxx
3. **[FFS]** xxx
4. xxxx.

# Conclusion

The observations captured are the following:

**Observation 1.** xxxx.

The proposals captured are the following:

**Proposal 1.** xxx

The following list shows the proposals above organized based on the suggested priority aiming to help during its meeting discussion:

**Proposals for easy agreement**

xxx

**Proposals for discussion (1st priority) or to be captured as FFS**

xxx

**Proposals for discussion (2nd priority) or to be captured as FFS**

xxx

# Annex: companies’ point of contact

|  |  |  |
| --- | --- | --- |
| **Company** | **Point of contact** | **Email address** |
| Intel Corporation | Yi Guo | Yi.guo@intel.com |
| Lenovo | Jie Shi | Shijie4@lenovo.com |
| Apple | Naveen Palle | naveen.palle@apple.com |
| Huawei, HiSilicon | Yulong Shi | shiyulong5@huawei.com |
| Futurewei | Yunsong Yang | yyang1@futurewei.com |
| Ericsson | Tuomas Tirronen | tuomas.tirronen@ericsson.com |
| Samsung | Jaehyuk Jang | jack.jang@samsung.com |
| OPPO | Haitao Li | lihaitao@oppo.com |
| ZTE, Sanechips | LiuJing | liu.jing30@zte.com.cn |
| LGE | HyunJung Choe | stella.choe@lge.com |
| China Telecom | WuZuping | Wuzp@chinatelecom.cn |
| vivo | Chenli | Chenli5g@vivo.com |
| Spreadtrum | Xiangdong zhang | Xiangdong.zhang@unisoc.com |
| Qualcomm | Linhai He | linhaihe@qti.qualcomm.com |
| Sierra Wireless | Serkan Dost | sdost@sierrawireless.com |

# Reference

1. R2-2106462 Summary 8.12.2.1 - Definition of RedCap UE and reduced capabilities (Intel)
2. R2-2106521 [offline 105] Definition of RedCap UE and reduced capabilities (Intel) Intel
3. R2-2106528 [offline 105] Definition of RedCap UE and reduced capabilities - second round Intel
4. TR 38.875
5. RP-210918, “Revised WID on support of reduced capability NR devices”
6. R2-2102017 Summary of offline 107 - [REDCAP] L2 capabilties and UE types Huawei
7. R2-2105234 Definition of RedCap UE and first look on capability signaling Ericsson
8. R2-2105634 Definition of RedCap UE type and reduced capabilities Huawei, HiSilicon
9. R2-2104927 RedCap UE capability and constraining of reduced capabilities Intel Corporation
10. TS 38.306 g40
11. TS 38.331 g41