**3GPP TSG-RAN WG2 Meeting #111 electronic Draft R2-2008191**

**Elbonia, Aug 17th – 28th 2020**

**Agenda item:** 8.11.12.1

**Source:** Intel Corporation

**Title:** Summary of discussion [109][REDCAP] Reduced capability signalling framework (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the summary of below offline discussion:

**[AT111e][109][REDCAP] Reduced capability signalling framework (Intel)**

Scope: Discuss the proposals in [R2-2006751](file:///C:\Data\3GPP\Extracts\R2-2006751-redcap-capabilty-framework.docx), [R2-2006911](file:///C:\Data\3GPP\Extracts\R2-2006911%20Framework%20and%20Principles%20for%20Reduced%20Capability.docx) and [R2-2006605](file:///C:\Data\3GPP\Extracts\R2-2006605_Defining%20and%20constraining%20UEs%20with%20reduced%20capabilities.docx). The intention is to identify design alternatives, collect company views and, whenever possible, also narrow down the proposals.

Initial intended outcome: summary of the offline discussion with e.g.:

  List of agreeable proposals (if any)

  List of proposals that require online discussions

Initial deadline (for companies' feedback): **Monday 2020-08-24 22:00 UTC**

Initial deadline (for rapporteur's summary in R2-2008191):  Tuesday 2020-08-25 02:00 UTC

Status: Ongoing

# Discussion

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

|  |  |
| --- | --- |
| Company | Delegate contact |
| COMPANY\_NAME | NAME ([email@address.com](mailto:email@address.com)) |
| Intel | yi.guo@intel.com |
| Qualcomm | Linhai He, linhaihe@qti.qualcomm.com |
|  |  |
| Nokia | Jussi Koskinen (jussi-pekka.koskinen@nokia.com) |
| OPPO | lihaitao@oppo.com |
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| Ericsson | tuomas.tirronen@ericsson.com |
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| Apple | Naveen Palle (naveen.palle@apple.com) |
|  |  |

As indicated by chairman, following contributions are considered in this offline discussion:

[1] R2-2006751 Reduced capability signalling framework Intel Corporation discussion Rel-17 FS\_NR\_redcap

[2] R2-2006911 Framework and Principles for Reduced Capability Ericsson discussion FS\_NR\_redcap

[3] R2-2006605 Defining and constraining UEs with reduced capabilities Qualcomm Inc discussion Rel-17 FS\_NR\_redcap

Based on the study item scope as below, two aspects need to be discussed, i.e. how to define the reduced capabilities, and how to ensure reduced capabilities are only used for intended use cases.

*Study standardization framework and principles for how to define and constrain such reduced capabilities – considering definition of a limited set of one or more device types and considering how to ensure those device types are only used for the intended use cases [RAN2, RAN1].*

## **How to define the reduced capabilities**

**Question 2.1-1 The need of device type**

As mentioned in the SID “considering definition of a limited set of one or more device types”;

[3] mentioned “*Since the SID requires RedCap UEs to be explicitly identifiable, we think they should be explicitly defined too*.”;

[1] mentioned “*defining device types can make it easier for access restrictions and check device use. It is also conceptually simpler, especially as an industry, to define certain device types for certain applications such as wearables, video surveillance and the device capability reduction that is allowed for these device types. Care should be taken though to minimise the number of device types that need to be defined to avoid long discussions as with LTE UE categories.*”

[2] mentioned “*Although these are strictly market-related strategies and discussions, 3GPP can facilitate the market development by defining specific device types with limited range of possible configurations.*

*3GPP could introduce a definition of a RedCap UE with certain capabilities (or certain combinations of capabilities) or the standard can allow any combination taking into account the minimum requirements and further leave it for markets to avoid the production of RedCap chipsets with multiple combinations of capabilities.*”

**Summary**, [1] [2] [3] all considered to have device type concept. Device type can be used:

* access restriction;
* check the intended use cases;
* avoid fragmented market by limited number of device type;

**Potential conclusion 1:** **Device types concept is introduced for RedCap devices.**

**Question 2.1-1: Companies are invited to provide view on potential conclusion 1.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree or disagree** | **Remark** |
| Qualcomm | Agree | We agree with all the arguments cited above. |
| Nokia | Disagree | It is not clear to us what is meant by “device type concept” and wording of the proposal is not acceptable. However UE capabilities needs to be introduced for REDCAP UEs. RAN2 needs to agree needed functionality for REDCAP UEs and related capabilities can be introduced later. In some scenarios early capability indications might be needed e.g. in cases where UE capabilities are not available in the gNB during connection establishment etc. |
| OPPO | Agree |  |
| Xiaomi | - | I check the [R2-2006751](file:///C:\Data\3GPP\Extracts\R2-2006751-redcap-capabilty-framework.docx), and it seems a little confused me by the “device type concept”. Does this mean the “UE categories” like in LTE to define UE capabilities as compared to the explicit capability signalling in NR? If so, I guess the existing UE capability signalling can be used as baseline to indicate reduced capabilities for RedCap UE；To introduce the “UE categories” as in LTE can be further considered.  Or does that mean the early capability indications of Redcap devices for initial access that the network can identify it? If so, I guess it will depends on more RAN1’s input. The RAN1 is discussing whether early identification is needed or not and how to achieve this. See our more comments on Q3. |
| Futurewei | Agree with comments | We see this more as an indication that UE would have reduced capability than normally required (# of antenna, BW, etc). It can be used with UE’s subscription to authorize the reduction of capabilities. It can also be used for access restriction and control.  We don’t see “types” defined for different use cases, or different sets of capabilities. |
| Ericsson | Disagree | We don't agree to the current formulation in the proposal. As pointed out by Nokia, the formulation is unclear on what a "device type concept" actually is, so it would not be clear what we agree to.  We think the existing capability signaling framework should be taken as baseline, and new capabilities characteristic to Redcap UE should be defined where needed, e.g. for maximum BW of 20 MHz (for FR1). UE with such capability, or minimum set of capabilities, would then correspond to a "Redcap UE", a concept which can be used e.g. in AS signaling when checking for access restriction. There should be no need for more than one type of Redcap UE from AS signaling/procedures perspective. On top of that, we don't see a need to define a broader "device type concept". |
| Convida Wireless | Agree | The exact definition of device types and how they are specified can be done during the Work Item. |
| Apple | Agree with comments | We are not keen on defining types to be used in RAN2 signaling extensively, but rather for marketing, and for “broader” restriction. We think the NWs are already flexible in handling a variety of UEs and the relaxation of many capabilities that will be part of RedCap do not require that the NW “broadcast” it’s filtering of what sort of RedCap UEs it supports by listing a big list of these capabilities in broadcast, for defining access restriction. We think probably BW and SCS limitations are important and so a broad types (2 or 3) based on these can be defined. |
|  |  |  |

**Question 2.1-2 The relationship between device type and capabilities**

[1], *This gives two options on how device types are used and signalled.*

*Option 1) Certain UE capabilities are only captured in the device type definition*

*Option 2) UE capabilities are always signalled explicitly and device type is an additional concept*

*There is no fundamental reason to move away from the legacy NR method of explicitly signalling UE capability. The main motivation for using device type is to make it easier to control access and for industry classification. If device types are used to define UE capabilities, it becomes similar to UE categories of LTE and can quickly result in increasing number of types and fragmentation. However, there is no need to define a device type for every UEs – it only needs to be done where there is a need to identify or restrict UE access based on some limited reduced capabilities and only a small number of device types need to be defined.*

[2] “*Observation 4 The existing UE capabilities framework can be reused to enable, beside the minimum set of capabilities RedCap UEs, more advanced features in RRC\_CONNECTED.”*

[3] also mentioned “*We think this verification can be done by performing a capability match between UE’s reported radio capability and the set of radio capabilities used in defining UE’s RedCap type. The rationale behind this check is that even if a UE falsely reports its UE type, it is less likely that it would falsely report its radio capabilities to gNB.*”

**Summary**, [1] [2] [3] proposed the similar way on the relationship between device type and the UE capabilities, i.e.the existing UE capabilities framework can be reused,  UE capabilities on redcap are always signalled explicitly and device type is an additional concept.

**Potential conclusion 2:** **The existing UE capabilities framework can be reused, UE capabilities on redcap are always signalled explicitly and device type is an additional concept.**

**Question 2.1-2: Companies are invited to provide view on potential conclusion 2.**

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| --- | --- | --- |
| **Company** | **Agree or disagree** | **Remark** |
| Qualcomm | Agree | We agree with all the arguments cited above. |
| Nokia | Disagree | We think that traditional UE capability framework is sufficient, and we see no motivation to introduce new device type concept. |
| OPPO | Agree |  |
| Xiaomi | - | See above. |
| Futurewei | Agree |  |
| Ericsson | Partly agree | The existing UE capabilities framework can be re-used.  Not clear what "UE capabilities on redcap are always signaled explicitly" means – we think the existing capability signaling procedures can be re-used. Possible need for early signaling needs to be studied, and if such is needed, then implicit or explicit indication that the UE is a Redcap UE would be needed.  We don't see additional device type concept on top of our reply to Q2.1-1 is needed. |
| Convida Wireless | Agree |  |
| Apple | Agree | Device type (if we agree to it) is an additional concept, but the existing UE cap framework can easily handle the RedCap UE requirements. Only access restriction needs to be addressed, and here we prefer a very smple device type definition. |
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**Question 2.1-3 How to define the device type**

[1] “*However, there is no need to define a device type for every UEs – it only needs to be done where there is a need to identify or restrict UE access based on some limited reduced capabilities and only a small number of device types need to be defined.*

*Proposal #3: The number of device types should be minimised and* ***introduced only where essential to control UE accesses and industry classification*.**”

[2] “*It is possible that the definition of RedCap UEs will diverge in terms of features, capabilities and constraints regarding FR1 and FR2. For this reason, we believe two device types should be defined, one for each Frequency Range.*

*Proposal 1 One RedCap device type is defined per frequency range,* ***corresponding to minimum set of capabilities addressing the RedCap use cases****.”*

[3]” *One approach is to define them in specifications based on a set of radio capabilities that differentiate them from legacy R15/16 UEs, e.g. number of Tx/Rx antennas, maximum supportable BW, etc. The exact composition of this set can be discussed by RAN1.*

*For example, if only a single RedCap type is defined, we may define its feature set targeting a high-end use case (e.g. smart watch) and have low-end UEs (e.g. sensors) use radio capabilities to omit features that they do not support. That would enable a single UE implementation supporting wide range of use cases. If two RedCap types are defined, we can define one type targeting high-end UEs (e.g. smart watch) and the other for low end UEs (e.g. sensors).*

*Proposal 1. Only one, or at most two, RedCap type(s) needs to be defined in Rel-17,* ***based on a set of radio capabilities that differentiate them from legacy R15/16 UEs****.”*

**Summary**: [1] [2] [3] proposed similar way, i.e.

* The number of device types should be minimised and introduced only where essential to control UE accesses and industry classification, e,g, differentiate them from legacy R15/16 UEs, ( number of Tx/Rx antennas, maximum supportable BW, etc.). The exact composition of this set can be discussed by RAN1.

**Potential conclusion 3:** **The number of device types should be minimised and introduced only where essential to control UE accesses and industry classification, e,g, differentiate them from legacy R15/16 UEs, ( number of Tx/Rx antennas, maximum supportable BW, etc. ). The exact composition of this set can be discussed by RAN1.**

**Question 2.1-3: Companies are invited to provide view on potential conclusion 3.**

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| --- | --- | --- |
| **Company** | **Agree or disagree** | **Remark** |
| Qualcomm | Agree | As to the number of UE types, we think what goes into the definition of a UE type can depend on frequency range, but the number of UE types does not have to depend on how many FRs we have. Because the main use of UE type is for access restriction and access control. For that purpose, a serving cell never has to deal with two FRs at the same time. So one UE type is enough.  As to the defining capabilities, we think the general guideline is that they should define the **envelop** of capabilities that differentiate RedCap from legacy R15/15 UEs. Hence within this set, we may need to include some “minimum capabilities” too. For example, we need to define the minimum bandwidth that RedCap UEs need to support so that they can reuse Rel-15 SSB bandwidth and share the same network with legacy UEs. |
| Nokia | Disagree | See earlier comments |
| OPPO | Agree | We think at most two UE types should be introduced to avoid market fragmentation. |
| Xiaomi | - | It seem that the device type mentioned here is for early capability indications of Redcap devices for initial access as the rapporteur mentioned to “differentiate them from legacy R15/16 UEs “.  If RAN1 confirmed that the early identification is needed, we guess only one UE type for Redcap UE(e.g. NR-Redcap UE) is need and sufficient.  This” NR-Redcap UE” could let itself be identified by the network during the initial access with a minimum set of Redcap UE capabilities. i.e., a set of capabilities in terms of the minimum bandwidth, MIMO layer and modulation order etc. For other capabilities beyond the minimum set can at least be supported by the current NR capability framework. To introduce the “UE categories” as in LTE can be further considered. |
| Futurewei | Agree | One type, or an indication, can be used for Redcap UE to indicate reduced capability than normally required (# of antenna, BW, etc). Network use it to let RAN provide service to UE of lower capabilities. It can also be used for access restriction and control.  The traditional capability signalling is still used for Redcap UE to report its actual capabilities. There would be a new “minimum” capability (# of Antennas, BW, etc) defined for Redcap UE. |
| Ericsson | Agree | Similar view as Futurewei. See also our earlier comments.  We don't see need to have more than one general definition of a RedCap UE corresponding to minimum capability/capabilities such UEs would support (there might be need to separate FR1/FR2 with regards to some capabilities). Additional capabilities may be signaled on top, per existing framework.  A type definition could also include some restrictions on what a Redcap UE should be able to support – e.g. to avoid advanced UEs to be identified as Redcap UEs. This requires further discussion though. |
| Convida Wireless | Agree | We should strive to minimize the number of device types. The definition of each device type requires discussion, but in our view a maximum of 2 device types for each FR should be sufficient. |
| Apple | Agree | We agree with potential conclusion 3. We also agree that this needs to be discussed in RAN1, but RAN2 can provide guidance as well. If we really want to minimize the device types, we think the minimum BW support is a good starting point. |
|  |  |  |

**Question 2.1-4 How to capture the device type**

[1] “*Further, there has to be an unambiguous understanding of the capability associated with the device type when used to control access to the network. Only the capabilities that are reduced for this device types should be captured. It is proposed:*

*Proposal #4:* ***Device type and its associated capabilities (the reduced set of capabilities) is captured in specifications****.”*

[2] “ *As a final remark, the exact details of how to capture such device types in the specifications can be left for normative phase after the study item has completed. The study should focus on discussion of the possible number of different device types and whether there is need to (normatively) restrict the number of possible capability combinations, as discussed in Section 2.1.*

*Observation 6* ***The exact definition of device types and how they are captured in the standard is determined in the normative phase****.*

**Question 2.1-4: companies are invited to provide view on how to capture the device type:**

* **Option 1: Device type and its associated capabilities (the reduced set of capabilities) is captured in specifications.;**
* **Option 2: Discuss in normative phase;**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1 or option 2** | **Remark** |
| Qualcomm | Option 1 | We are not sure if these two options are exclusive. We think device type and its associated capabilities have to be defined in specs. We don’t expect how other means (e.g. dynamic signaling?) would work.  We also tend to agree with the assessment in [2] that the study phase can focus on discussion on possible number of device types and general guideline on how to define them. |
| Nokia | Option 2 | UE capability discussion are normally done in the late phase of the work item and we think we should follow that principle. |
| OPPO | Option 2 | After RAN1 studies what reduced set of capabilities are related to RedCap UEs, we can capture the device type in the normative phase. |
| Xiaomi | Option 2 |  |
| Futurewei | Option 2 | As commented before, we don’t see a linkage between a type and a set of capabilities, or something similar to the LTE UE “category” concept.  We see an indication to alert RAN of a lowered minimum UE capability. |
| Ericsson | Option 2 | Note that "how to capture device type" is premature as it is not yet clear what is needed. |
| Convida Wireless | Option 2 |  |
| Apple | Option 1, but | Similar views as Qualcomm. |
|  |  |  |

**Question 2.1-5 How to indicate the device type**

[1] “*On the other hand, signalling device type explicitly can help with verification of device type and its capability. As it is only a few bits, it is proposed:*

*Proposal #5:* *Device type is signalled as part of UE capability in addition to the full UE capabilities*.”

**Question 2.1-5: companies are invited to provide view on whether device type is signalled as part of UE capability in addition to the full UE capabilities:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or no** | **Remark** |
| Qualcomm | No | In our view, the main purpose of device type indication is for access restriction and access control. So UE signals its RedCap type during connection setup with core network, which then verifies it against UE’s subscription information. This core network entity typically does not need to know details of UE’s radio capabilities (e.g. # of antennas, max number of HARQ processes, etc). Therefore, device type is not signalled as a part of the legacy UE radio capability. |
| Nokia | no | We are not convinced that device type needs to be signalled in addition to traditional capabilities. It should be sufficient that the network is aware of supported features by the UE. |
| OPPO | No, but | We are not sure for the moment, in addition to the existing full UE capabilities, what else information is required in the network side to control RedCap UE’s access. At least we think the definition of RedCap device type should be specified, but wonder about the need to signal the device type to network.  Maybe this can be discussed in the normative phase and if companies all think a few bits do not matter, we are also ok to have it. |
| Xiaomi | - | See above.  If the the main purpose of device type indication is for initial access, RAN1 is discussing how to achieve that. If early identification can let UE be identified by the network as Redcap UE, we are not sure why the “*Device type*”needs to be signalled to the network？ |
| Futurewei | No | It is related to UE capability, but it is used more for authorizing UE’s permission of using reduced capability, and for access restriction and control of UE with reduced capabilities. The exact signaling of this indication can be determined in WI phase. |
| Ericsson | No | On top of existing capability signaling, we don't think an explicit "Redcap" capability is needed. It can be further discussed whether there is need to signal the type separately e.g. for early indication.  Especially if an early indication is needed (FFS) and specified, what would be the reason to have an additional separate UE capability? |
| Convida Wireless |  | We believe this can be discussed further during the SI to help develop a common RAN2 understanding, and then the detail of the signalling can be finalized in the normative phase. |
| Apple | No |  |

## **How to ensure those device types are only used for the intended use cases**

[1] “*As the UE signals its capabilities to the network irrespective of the solution chosen, it is possible for the network to check the device capability or type against intended use cases. This check could be by means of QoS of the bearers used by the device, checking against subscription parameters or PDU session types. The actual details of the checking can be handled by the network.*

*The SI objective of “checking device is used only as intended” can be met using existing capabilities or a device type.* “

[2] “*RAN can already reject an RRC connection establishment attempt e.g. based on the establishment cause provided in Msg3 or through higher layer mechanisms. Further access attempts can be delayed if rejected and it can be discussed whether these mechanisms should be updated or extended.*

*Observation 7 If UE requires a service which is not intended for RedCap UEs, the request can be rejected. RAN2 should further study whether the existing mechanisms should be extended*.”

[3] “*Proposal 2. Network should validate a UE’s RedCap indication against UE’s subscription to ensure it does not receive services unintended for RedCap UEs.*

*Proposal 3. Network can additionally perform capability match procedure between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type, to prevent a hacked or misconfigured UE from falsely reporting as a RedCap UE.* ”

**Summary**: Based on [1], [2] and [3], checking device is used only as intended can be met by using existing capabilities or a device type or cause value, etc., E.g: the network to check the device capability, device type or cause value against intended use cases based on subscription checking, rejection access requests etc..

**Potential conclusion 4:** The SI objective of “**checking device is used only as intended” can be met by using existing capabilities or a device type or cause value, etc.. Solution details need further discussion.**

**Question 2.2-1: Companies are invited to provide view on potential conclusion 4.**

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| --- | --- | --- |
| **Company** | **Agree or disagree** | **Remark** |
| Qualcomm | Agree |  |
| Nokia | disagree | We are not sure whether this requirement can be met by using existing capabilities or a device type etc. We think that RAN2 should discuss whether traditional devices are allowed to indicate the support for REDCAP functionality. |
| OPPO | Agree |  |
| Xiaomi | Agree |  |
| Futurewei | Agree with clarification | We assume that the term “existing capabilities” mean “existing capability signaling”. We also assume UE’s subscription is taken into account as well, though it is an operation done mainly in Core network. |
| Ericsson | Disagree | Establishment cause is one tool, but especially in case such would not be used, further study is needed. In particular, as the intended use or service cannot be determined by RAN alone, we think SA/CT should be involved when discussing such mechanism(s), and how and if to specify such. |
| Convida Wireless | Agree | RAN2 can discuss what enhancements, if any, should be made to improve how this is done. |
| Apple | Agree | In addition, we think NAS signaling can also contribute to this, during registration. |
|  |  |  |

**Potential solutions on how to ensure** **redCap device types are only used for the intended use cases:**

**Option 1**: RAN can already reject an RRC connection establishment attempt e.g. based on the establishment cause provided in Msg3 or through higher layer mechanisms.

**Option 2:** Network to validate a UE’s RedCap indication against UE’s subscription to ensure it does not receive services unintended for RedCap UEs.

**Option 2a**. Network can additionally perform capability match procedure between UE’s reported radio capabilities and the set of capability criteria associated with UE’s RedCap type, to prevent a hacked or misconfigured UE from falsely reporting as a RedCap UE. ”

**Option x**:

**Question 2.2-2: companies are invited to provide view on solutions ensure redCap device types are only used for the intended use cases:**

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| --- | --- | --- |
| **Company** | **Views on potential solutions** | |
| Qualcomm | We think both Option 2 and 2a are necessary. Option 1 alone is not sufficient.  If we understood correctly how Option 1 works, it may meet the requirement in a robust way – for example, a hacked RedCap UE may not report itself as RedCap in establishment cause and then get services that it is not intended for. Therefore, in addition to some type of indication by UE itself, network has to perform capability match procedure to ensure UE is telling the truth. | |
| Nokia | We think that RAN2 should discuss whether traditional UE can indicate support for REDCAP functionality. However such discussion can take place in the work item phase. |
| OPPO | We think all these solutions can be considered in the normative phase. Option 1 may have RAN2 impact on defining the new establishment cause. Option 2 and 2a may mainly have RAN3/SA2 impact. | |
| Xiaomi | We are also open to discuss these solutions. But I guess Option 2 and 2a may have RAN3/SA2 impact even SA3 if security is involved. | |
| Futurewei | Option 2 + Option 1 can be a starting point, and further details can be worked out in WI phase.  We are negative on Option 2a, as we don’t envision a type to be associated with a set of UE capabilities, leading us back to something similar to LTE UE category. | |
| Ericsson | Option 1 is existing RAN2 tool, which can be discussed further.  Option 2 is not in RAN2 scope and requires coordination with SA. Also "Redcap indication" is questionable at this point as it is not clear if and how such would be used.  Option 2a is a possibility, but requires further discussion on what capability combination is allowed for Redcap – i.e. whether there is some "upper limit" on what such UE should support to be categorized as Redcap UE. It would seem more reasonable to consider approach where capability is matched against subscription information but this again requires coordination with SA. | |
| Convida Wireless | Option 2 and 2a seem necessary in addition to Option 1. Details of the option 2 &2a solutions need to be coordinated with SA2. | |
| Apple | Option 2 is the starting point and option-1 is viable, but we are not sure about the rejection at MSG3. We assume RAN already has access-barring of some sort, and anyway RAN obtains the capability. | |
|  |  | |

# Summary

To be added: