3GPP TSG-RAN WG1 Meeting #110bis-e Draft R1-2210249

e-Meeting, 10th – 19th October 2022

**Agenda Item: 9.6.1**

**Title: FL summary #2 on Rel-18 RedCap UE complexity reduction**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# 1 Introduction

This feature lead (FL) summary (FLS) concerns the Rel-18 work item (WI) on enhanced support of reduced capability (RedCap) NR devices [1, 2]. This Rel-18 RedCap WI was preceded by Rel-17 RedCap WI [3, 4], a Rel-18 study item (SI) on further UE complexity reduction [5] and a RAN plenary discussion on the Rel-18 RedCap WI scope [6].

The core part of the WI [1] has the following objective and notes related to further reduced UE complexity:

|  |
| --- |
| **Complexity/cost reduction*** Further reduced UE complexity in FR1 [RAN1, RAN2, RAN4]
	+ UE BB bandwidth reduction
		- 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH, with 20 MHz RF bandwidth for UL and DL
		- The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.
	+ UE peak data rate reduction
		- Relaxation of the constraint (*vLayers*·*Qm*·*f* ≥ 4) for peak data rate reduction
		- The relaxed constraint is, e.g., 1 (instead of 4).
		- The parameters (*vLayers*, *Qm*, *f*) can be as in Rel-17 RedCap.
	+ Both 15 kHz SCS and 30 kHz SCS are supported.
	+ Aim to define at most one Rel-18 RedCap UE type for further UE complexity reduction.
	+ The existing UE capability framework is used, and changes to capability signalling are specified only if necessary. By default, all UE capabilities applicable to a Rel-17 RedCap UE are applicable unless otherwise specified.

Notes:* The work defined as part of this WI is not to overlap with LPWA use cases.
* Coexistence with non-RedCap UEs and Rel-17 RedCap UEs should be ensured.
* This WI considers all applicable duplex modes unless otherwise specified.

Check in RAN#98-e regarding:* Whether UE peak data rate reduction for UE is limited only with UE BB bandwidth reduction or standalone
* Whether or not/how a separate early indication can be supported
* Other restrictions of the WI (e.g., connectivity restrictions, band, etc.)
 |

This document summarizes contributions [7] – [35] submitted to agenda item 9.6.1 and the following email discussion:

|  |
| --- |
| [110bis-e-R18-RedCap-01] Email discussion on further UE complexity reduction by October 19 – Johan (Ericsson)* Check points: October 14, October 19
 |

The issues in this document are tagged and color coded with High Priority or Medium Priority. The issues that were in the focus of this round of the discussion are furthermore tagged FL1 and FL2. The initial FLS is available in [36].

Follow the naming convention in this example:

* *eRedCapFLS2-v000.docx*
* *eRedCapFLS2-v001-CompanyA.docx*
* *eRedCapFLS2-v002-CompanyA-CompanyB.docx*
* *eRedCapFLS2-v003-CompanyB-CompanyC.docx*

If needed, you may “lock” a discussion document for 30 minutes by creating a checkout file, as in this example:

* Assume CompanyC wants to update *eRedCapFLS2-v002-CompanyA-CompanyB.docx*.
* CompanyC uploads an empty file named *eRedCapFLS2-v003-CompanyB-CompanyC.checkout*
* CompanyC checks that no one else has created a checkout file simultaneously, and if there is a collision, CompanyC tries to coordinate with the company who made the other checkout (see, e.g., contact list below).
* CompanyC then has 30 minutes to upload *eRedCapFLS2-v003-CompanyB-CompanyC.docx*
* If no update is uploaded in 30 minutes, other companies can ignore the checkout file.
* Note that the file timestamps on the server are in UTC time.

In file names, please use the hyphen character (not the underline character) and include ‘v’ in front of the version number, as in the examples above and in line with the general recommendation (see slide 16 in [R1-2208323](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208323.zip)), otherwise the sorting of the files will be messed up (which can only be fixed by the RAN1 secretary).

To avoid excessive email load on the RAN1 email reflector, please note that there is NO need to send an info email to the reflector just to inform that you have uploaded a new version of this document. Companies are invited to enter the contact info in the table below.

**FL1 Question 1-1a: Please consider entering contact info below for the points of contact for this email discussion.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Point(s) of contact** | **Email address(es)** |
| Huawei, HiSilicon | Frank Long | frank.longyi@huawei.com |
| MediaTek | Chiou-Wei Tsai | cw.tsai@mediatek.com |
| FUTUREWEI | Vip Desai | vipul.desai@futurewei.com |
| Nokia, NSB | Rapeepat Ratasuk | rapeepat.ratasuk@nokia-bell-labs.com |
| Qualcomm | Yongjun Kwak | yongkwak@qti.qualcomm.com |
| China Telecom | Jing Guo | guojing6@chinatelecom.cn |
| CATT | Yongqiang FEI | feiyongqiang@catt.cn |
| Vivo | Lihui Wang | wanglihui@vivo.com |
| ZTE, Sanechips | Youjun Hu | hu.youjun1@zte.com.cn |
| NTT DOCOMO | Mayuko Okano | mayuko.okano.ca@nttdocomo.com |
| Spreadtrum | Sicong Zhao | sicong.zhao@unisoc.com |
| SONY | Martin Beale | martin.beale@sony.com |
| CMCC | Lijie Hu | hulijie@chinamobile.com |
| Panasonic | Shotaro Maki | maki.shotaro@jp.panasonic.com |
| Xiaomi | Xuemei Qiao | qiaoxuemei@xiaomi.com |
| Ericsson | Sandeep Narayanan Kadan Veedu | sandeep.narayanan.kadan.veedu@ericsson.com |
| Samsung | Feifei Sun | feifei.sun@samsung.com |
| Samsung | Min Wu | min1.wu@samsung.com |
| NEC | Takahiro Sasaki | takahiro.sasaki@nec.com |
| LGE | Jay KIM | jaehyung.kim@lge.com |
| Sequans | Efstathios Katranaras | ekatranaras@sequans.com |
| Intel | Yingyang Li | yingyang.li@intel.com |
| OPPO | Zhisong Zuo | zuozhisong@oppo.com |
| Sharp | Xiaojun Ma | xiaojun.ma@cn.sharp-world.com |

# 2 UE BB bandwidth reduction

**Maximum number of PRBs**

Several contributions [11, 15, 16, 28, 29] propose that the maximum number of contiguous PRBs for PDSCH and PUSCH is 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS. A few contributions [8, 13] propose 25 PRBs and 12 PRBs, respectively. One contribution [14] proposes 27 PRBs and 13 PRBs, respectively. One contribution [35] proposes 28 PRBs and 14 PRBs, respectively. A couple of contributions [18, 20] propose to send an LS to RAN4 to ask about the maximum number of PRBs.

For information,

* For 15 kHz SCS, the occupied bandwidth for {25, 26, 27, 28, 29} PRBs is {4.50, 4.68, 4.86, 5.04, 5.22} MHz
* For 30 kHz SCS, the occupied bandwidth for {11, 12, 13, 14, 15} PRBs is {3.96, 4.32, 4.68, 5.04, 5.40} MHz

Based on the above considerations, the following proposal can be considered.

**FL1 High Priority Proposal 2-1a: For UE BB bandwidth reduction, for PDSCH (for both unicast and broadcast) and PUSCH, down-select between the following options for the maximum number of contiguous PRBs:**

* **Option 1: 28 PRBs for 15 kHz SCS and 14 PRBs for 30 kHz SCS**
* **Option 2: 27 PRBs for 15 kHz SCS and 13 PRBs for 30 kHz SCS**
* **Option 3: 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS**
* **Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Y/N** | **Preferred option(s),if any** | **Comments** |
| Huawei, HiSilicon |  | Option 4 | Option 4 is in line with the current PRB number specified in RAN4 for 5MHz channel bandwidth. |
| Nordic  | Y | Option 3 |  |
| MediaTek | N |  | In general, we are OK with PUSCH to be confined with 5MHz physically contiguous resource blocks. However, for PDSCH in the main bullet, we have concerns and cannot agree to it before **we clarify further whether/how Rel-18 eRedCap can *indeed* reduce its post-FFT buffer size for *most* of the OFDM symbols in a slot.** 1. As agreed in RAN#97e and promised by RAN chair, PR3 can be revisited. We are not fine with confining PDSCH resource allocation to 5MHz (i.e. BW3). PR3 vs BW3 discussion should be revisited for both broadcast and unicast PDSCHs.
2. For broadcast PDSCHs, based on the coverage evaluation results in TR 38.865, it is more reasonable to allow gNB to transmit them with resource allocation bandwidth more than 5MHz.
3. For unicast PDSCHs, we currently still believe that post-FFT buffer in eRedCap will likely support up to 20MHz for almost every symbol, if not all, in a slot (taking lower PDCCH decoding capability, support for CSI-RS up to 20MHz, and LTE-NR dual-mode support into account). Hence, we prefer to understand companies’ assumption UE’s post-FFT buffer size first.

With the above, we would like to revise the FL’s proposal as follows: **Revised Proposal: For UE BB bandwidth reduction, for ~~PDSCH (for both unicast and broadcast) and~~ PUSCH, down-select between the following options for the maximum number of contiguous PRBs:*** **Option 1: 28 PRBs for 15 kHz SCS and 14 PRBs for 30 kHz SCS**
* **Option 2: 27 PRBs for 15 kHz SCS and 13 PRBs for 30 kHz SCS**
* **Option 3: 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS**
* **Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS**
 |
| FUTUREWEI |  |  | We proposed 12 RBs for the at least the PUSCH. |
| Nokia, NSB | Y | Option 4 | In our view, we prefer to stay with the RAN4 numbers for channel bandwidth of 5 MHz.In the SI, we studied 11 vs 12 PRBs for 30 kHz SCS. However, the performance improvement shown in the SI is small. For PUSCH, we don’t see the need to support 12 PRBs for transform precoding as we can have a mix of different UE types in the same BWP. In addition, cell-edge UEs where DFT-S-OFDM would be beneficial would not be using more than few PRBs. Finally, the peak data rates can be met with 25/11 PRBs.In addition, it is important to support the same number of PRBs for PDSCH and PUSCH to avoid implementation complexity. |
| Qualcomm | Y | Option 3 | We are fine with the current proposal for now even though we prefer option 3. RAN1 assumed option 3 or option 4 for complexity and coverage analysis during the study item so we may choose one from the two options unless there is good justification for the other options. |
| China Telecom | Y |  | We are generally fine with the current proposal. We think only one option can be selected for both PDSCH and PUSCH to reduce the unnecessary workload. |
| Sharp |  | Option3/4 | The conclusions in TR regarding bandwidth reduction, peak data rate reduction, and coverage recovery are based on the evaluations with option 4 or option 3. Aside from the recommendations of the SI, we do not see a reason for the introduction of a wider frequency band. |
| CATT | Y | Option 1, 2 or 3 | The number of PRB is important, especially when we calculate the constraint of v\*Qm\*f when adopting PR1 as add-on. We should be more careful in this issue.Option 4 is under the assumption of BW1— the RF, BB and BWP are within 5 MHz, so a lot of edge PRBs are wasted as guardband. The group just used Option 4 for ‘coverage evaluation’. It is not justified for current designed, i.e. RF and BWP is 20 MHz.Option 2 is with the largest PRB number <5MHz, which is justified to adopted. Option 1 is also OK to us if the majority doesn’t mind the bandwidth (5.04 MHz) is very slightly larger than 5 MHz. It is more flexible than Option 2 indeed.Option 3 is not our first preference, but at least the strange number of 11 PRB is avoided in the case of SCS=30kHz.  |
| vivo |  |  | For the main bullet, we suggest to remove the wording of “**contiguous**”. Even for PUSCH, from the specification perspective, the non-continuous resource allocation can be supported for CP-OFDM waveform. We would also like to echo MTK’s suggestion to first clarify whether/how Rel-18 eRedCap can reduce its post-FFT buffer size. It is not clear from the main bullet the maximum number of PRBs is for UE to buffer, receive, process or for network’s scheduling?  |
| ZTE, Sanechips | Y | Option3 or Option4 | For option1 and option2, the maximum number of PRBs is increased to 27 or 28, which would increase the UE complexity and is not aligned with our main target, i.e. complexity reduction.Option3 can provide some additional benefits, e.g., performance, data rate and would not have impacts on UE complexity. For option4, it is in line with the current PRB number in RAN4, which is also can be a candidate. |
| DOCOMO | Y |  | We support this proposal at this point. While Option 1/2 were not studied in SI phase, the coverage would be improved without significant increase of UE complexity unless the post-FFT data buffering BW exceeds 5MHz. Therefore, we are open to discuss including Option 1/2. We think it would affect to the peak rate calculation, i.e., how the constraint on *vLayers*·*Qm*·*f* can be relaxed, and such aspect can be considered together. |
| Spreadtrum | Y | Option 4 | We only evaluated the cost/complexity for option 4 and option 3 at the SI phase. In general, larger PRBs corresponding to higher peak data rate and hence larger buffer requirements.Besides, if the bandwidth of a cell is 5MHz, larger PRB number may not be able to meet the guard band requirements. Therefore, if the PRB number is not 11/25 (different from the value in RAN4’s spec 38.101 table Table 5.3.2-1), we prefer to send an LS to RAN4 to ask about the maximum number of PRBs. |
| SONY | Y | Option 3 or 4 | This is a good list for down-selection purposes.Regarding option 4, we agree with Nokia that for DFT-s-OFDM, only a few PRBs are likely to be used at the cell edge, hence the transform precoding issue with 11 PRBs isn’t a big deal. We would also be OK with option 3 (12 PRBs).  |
| CMCC | Y | Option3 | Compare to BW3 and PR3, we support BW3, with proper design during WI, BW3 can achieve the post FFT buffer benefit.So we think the hardcode limit RB number of BB reduction should be contiguous PRBs. This does not mean the allocation within maximum 5MHz need to be contiguous, but the span of PDSCH/PUSCH allocation is less than 5MHz. 12RB is better for CORESET resource allocation, since the *frequencyDomainResources* of *ControlResourceSet* is inidicated with a granularity of 6RBs and 12 is also a valid RB number for DFT-S-OFDM resource allocation. |
| Panasonic | Y with update | Option 3 or 4 | We would propose to remove the confusing word “contiguous” because the allocation could be non-contiguous PRBs based on the outcome of the discussion related to the Question 2-6a.Among the options, we prefer Option 4 in general. The current number of RBs is enough for the required peak data rate. RAN4 impact should be avoided. For UL, we understand the argument for SC-FDMA needs to be specific number. Therefore, 12 PRBs for 30 kHz SCS is reasonable for UL. |
| Xiaomi | Y | Option 4 | Support option 4 for both (broadcast and unicast) PDSCH and PUSCH. We believe it is sufficient to follow the current PRB number specified in RAN4 for 5MHz channel bandwidth, and can’t see the necessity to involve other specifications. |
| Ericsson | Y | Option 1 | We think Option 1 provides a good balance between complexity reduction and link performance, in particular for broadcast channels. For instance, the link performance loss for SIB1 can be reduced by supporting more PRBs. Also, the complexity reduction is more or less the same for Option 1 and other options.Note that unlike RF bandwidth reduction, the UE BB bandwidth reduction for PDSCH/PUSCH is like scheduling restriction which does not need to consider RAN4 requirements, e.g., on guard bands. We are also fine with making Option 1 a WA and sending an LS to RAN4 asking for their input. |
| Samsung | Y | Option 3 or option 4 | We are fine for the proposal. We prefer option 3 or option 4. |
| NEC | Y | Option 2 | As RF BW is decided up to 20MHz, RAN1 does not need to stick to maximum number of RBs defined for 5 MHz RF channel bandwidth. |
| LGE | Y | Option 3/4 | Okay to down-select from the complete list of proposals.We prefer to further consider Option 3 and Option 4. As we don’t have the same interference issues for Option BW3 as we had for 5 MHz UE channel bandwidth, allowing 12 PRBs for 30 kHz SCS seems to be a reasonable option to consider. |
| Sequans | Y |  | We support in principle the proposal for later down-select.Agree to remove “contiguous” but clarify that total data PRB allocation is within 5MHz. |
| Intel | Y | Option 4 | We prefer to clarify single option will be down selected. 11 PRB is fine for uplink since there is no issue for 10Mbps target data rate.  |
| FL2 | Based on received responses, the following updated proposal can be considered. The PDSCH case can be revisited once other aspects (e.g., resource allocation) have progressed further.**High Priority Proposal 2-1b: For UE BB bandwidth reduction, for ~~PDSCH (for both unicast and broadcast) and~~ PUSCH, down-select between the following options for the maximum number of ~~contiguous~~ PRBs:*** **Option 1: 28 PRBs for 15 kHz SCS and 14 PRBs for 30 kHz SCS**
* **Option 2: 27 PRBs for 15 kHz SCS and 13 PRBs for 30 kHz SCS**
* **Option 3: 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS**
* **Option 4: 25 PRBs for 15 kHz SCS and 11 PRBs for 30 kHz SCS**
 |
| OPPO | Y | Option 3 | 11 PRB will be greatly restrict the resource in of DFT pre coded PUSCH. It means even with BWP of 10/20MHz, The UE can be allowed with very few PRB and thus waste the processing capability.We agree that the UE can follow the restriction of 11RB when system bandwith is 5MHz, that is for guard band reservation as purposed in RAN4 specificaiton. |
| Nordic  | Y | Option 3 | If only PUSCH is discussed, contiguous can be left there. Even with intra-slot hopping the transmission is contiguous at a given time/symbol. |
| Nokia, NSB | N | Option 4 | We would like to have the same number of PRBs for PDSCH and PUSCH to avoid implementation complexity. Therefore, we cannot accept doing the down-selection for PUSCH only. We would like “**~~PDSCH (for both unicast and broadcast) and~~**” to be added back.Our preference is Option 4 as explained in previous round.  |
| FUTUREWEI | Y | Option 3 or 4 | While our first preference is option 3 was for DFT-S-OFDM considerations, but given some explanations regarding scheduling and UL data rate, we would also be ok with option 4. We do not support options 1 nor 2 since one motivation for those options was improving DL performance.  |
| Apple  |  | Opt.4  | Other options, except Opt.4, introduces irregular RB numbers that are not specified by RAN4 yet, which potential request new implementation and RAN4 requirement. We do not see strong justification to do these.  |
| Sharp | Y | Option3 or 4 | Agree with Nodic that “contiguous” should be left there. |
| Lenovo |  |  | Since “contiguous” has been removed from the main proposal, we think “PDSCH (for both unicast and broadcast” shall be kept. Same with Nokia, we also support to have same number of PRBs for PDSCH and PUSCH.  |

**Separate initial BWP**

Several contributions [9, 14, 15, 24, 28, 32, 33] propose that the initial DL/UL BWP operation framework for Rel-17 RedCap can be reused for Rel-18 RedCap. A few contributions [15, 28] express that there is no need to configure a separate initial BWP for Rel-18 RedCap UEs. One contribution [18] proposes to reuse MIB-configured initial DL BWP for Rel-18 RedCap. One contribution [24] proposes to discuss whether to support more than one initial DL/UL BWP.

**High Priority Proposal 2-2a: For UE BB bandwidth reduction, for a cell supporting both Rel-17 and Rel-18 RedCap UEs,**

* **The Rel-18 RedCap UEs can share the same separate DL/UL BWP as the Rel-17 RedCap UEs.**
* **FFS: whether to support an additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon | Y | Not sure why additional initial DL/UL BWP specific to Rel-18 RedCap UEs is necessary. But OK for FFS at this stage. |
| Nordic  | Y | Hopefully “share” does not preclude R18 specific parameters in that BWP. |
| FL1 | Based on the proposal, the online (GTW) session on Monday 10th October made this agreement:Agreement:For a cell supporting both Rel-17 and Rel-18 RedCap UEs,* The Rel-18 RedCap UEs can share the same separate initial DL/UL BWP as the Rel-17 RedCap UEs.
* FFS: whether to support an additional separate initial DL/UL BWP specific to Rel-18 RedCap UEs
 |
| Spreadtrum | As we commented at the GTW online, for some band (LTE reframing band or IOT band), maybe a cell can only support R18 RedCap (skip R17 RedCap), and then, how to configure separate initial DL/UL BWP for R18 RedCap needs to be confirmed, new IE for Rel.18 or reuse R17 RedCap IE? This issue can be a part of the FFS in the above agreements. |
| LGE | In the concerned case from Spreadtrum, we think the same mechanism for configuring a separate initial DL/UL BWP can be reused without an issue. Whether it is a new IE or existing IE since Rel-17 RedCap, can be decided in RAN2. We are not sure if it is part of the FFS, but the agreement above doesn’t seem to affect the discussion on this aspect. I mean we can discuss in RAN1 if needed. |

**Maximum span for the resource allocation**

Several contributions [10, 11, 16, 19, 21, 22, 25, 28, 29, 30, 32, 33, 34] discuss whether the resource allocation should span a bandwidth of maximum 5 MHz for PDSCH (for both unicast and broadcast) and PUSCH, or support distribution within 20 MHz bandwidth with a limitation of the maximum number of PRBs (at least for PDSCH). One contribution [25] suggests an approach where the PDSCH processing bandwidth is up to 5 MHz whereas the instantaneous PDSCH transmission bandwidth can be wider.

For unicast transmissions, some contributions [8, 9, 15, 33] propose that scheduled bandwidth does not exceed 5 MHz.

For broadcast PDSCH transmissions, some contributions [8, 15, 22, 25, 33] propose that the allocation can be larger than 5 MHz even though the UE only receives 5 MHz, whereas one contribution [24] expresses that the UE should not be expected to receive broadcast channels with wider bandwidth than 5 MHz. One contribution [9] proposes that this should apply for SIB but not for other broadcast transmissions, and a couple of contributions [26, 34] propose that the UE should receive the full bandwidth of some broadcast transmissions (e.g., SIB).

**High Priority Proposal 2-3a: For UE BB bandwidth reduction, for SIB1 (PDSCH) shared between Rel-18 RedCap UEs and other types of UEs, down-select between the following options:**

* **Option 1: Restrict the scheduling of SIB1 to be within 5 MHz**
* **Option 2: Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, HiSilicon |  | Option 2 | Since 20Mhz SIB1 exists in current NR network and Rel-18 RedCap UEs are expected to share the same initial BWP with Rel-17 RedCap UEs, Option 1 seems not practical solution. |
| Nordic  | Y | Option 2 |  |
| FL1 | Based on the proposal, the online (GTW) session on Monday 10th October made this agreement:Agreement:For UE BB bandwidth reduction, for SIB1 (PDSCH) to Rel-18 RedCap UEs, down-select between the following options,* Option 1: Restrict the scheduling of SIB1 to be within 5 MHz
* Option 2: Allow the scheduling of SIB1 to be larger than 5 MHz (as in legacy operation)
* FFS: whether 5MHz is assumed to be physically contiguous
 |

**FL1 High Priority Proposal 2-4a: For UE BB bandwidth reduction, for paging channel (PDSCH) shared between Rel-18 RedCap UEs and other types of UEs, down-select between the following options:**

* **Option 1: Restrict the scheduling of paging channel to be within 5 MHz**
* **Option 2: Allow the scheduling of paging channel to be larger than 5 MHz (as in legacy operation)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, HiSilicon | Y | Option 1 | Paging is not periodic signaling as SIB1. Performance loss caused by option 2 needs careful consideration. |
| Nordic  | Y | Option 2 |  |
| MediaTek | Y | Option 2 | Our view is that transmission bandwidth for all broadcast PDSCHs should be allowed up to 20MHz as legacy operation. UE BB bandwidth reduction does not mean transmission bandwidth reduction at gNB. |
| FUTUREWEI | Y |  | Both options can further be discussed. |
| Nokia, NSB | Y | Option 2 | We share similar view as MediaTek. Option 2 would allow the gNB to page both Rel-18 RedCap and legacy UEs in the same message without performance impact to the legacy UEs. The gNB also would not need to be aware what UE type it is paging. We do not see the need for the network to be aware of or have separate broadcast transmission for Rel-18 RedCap versus legacy UEs. |
| Qualcomm | Y |  | Need further discussion between two options for paging. |
| Lenovo | Y | Option 2 | It is not expected to introduce restrictions to legacy UEs. On the other hand, paging performance was not evaluated during SI. As HW mentioned, the performance loss might need to be considered. |
| China Telecom | Y |  | Fine with the current proposal. It needs down-selection for paging after further discussion. |
| Sharp | Y |  | It can be same as SIB1  |
| CATT | Y |  | Same handling to agreed Proposal 2-3a can be applied. |
| vivo | Y | Option 2 | We think Option 1 can be realized by NW implementation for example, currently the PO occasion is determined by UE ID, NW can configure different/separate PO occasions for R18 eRedCap UE and other UEs. Then the restriction for paging channel to be within 5 MHz is only for Rel-18 RedCap UEs. No impacts on other UE types. In addition, similar as for SIB1 discussion, following FFS should be added:FFS: whether 5MHz is assumed to be physically contiguous |
| ZTE, Sanechips | Y | Option 2 | Impacts on legacy UE should be avoided. And performance loss issue by Rel-18 RedCap UE incomplete receiving can be further discussed. |
| DOCOMO | Y, but | Option 2 | We have a similar clarification question as SIB1 discussed on GTW session whether this proposal preclude the case where the paging PDSCH resources are not shared between Rel-18 RedCap and other types of UE.In our view, it is not preferable to restrict the paging PDSCH BW for legacy UEs, thus we support option 2 so far. As commented by some companies, it should be noted that these options are from gNB scheduling perspective and we think Rel-18 RedCap receive the PDSCH with 5MHz post-FFT data buffering even if option 2 is supported. |
| Spreadtrum | Y | Option 2 |  |
| SONY | Y |  | Both options should be discussed. From a UE perspective, we would prefer option 1, but we appreciate that option 2 has network benefits. |
| CMCC | Y |  | Paging performance has not be evaluated, if shared paging with larger than 5MHz bandwidth can not be correctly decoded, separate paging search space can be configured.  |
| Panasonic | Y |  | As the SIB1 agreement made on Monday, we would propose to add the FFS below:FFS: whether 5MHz is assumed to be physically contiguous |
| Xiaomi |  |  | Before discussing it, we think it is necessary to clarify whether the cost of post-FFT buffering will be reduced. If not, as analysis in our contribution, the cost of eRedCap will be increased about 1% compared with cost reduction of post-FFT buffering; while, the transmission performance can be guaranteed with HARQ combination. Based on this, option 2 can be adopted without any spec efforts. Otherwise, to guarantee the transmission performance, we support to involve option 1 and it is necessary for gNB to acknowledge whether it is a eRedCap UE before separate paging PDSCH is scheduled.  |
| Ericsson | Y | Option 2 | Similar view as CATT. Also, further enhancements/restrictions (for non-shared case), if any, can also be discussed under Q2-8a.We think it can be left to gNB whether or not to transmit a paging message containing a paging record for a Rel-18 RedCap UE on a PDSCH with bandwidth > 5 MHz or < 5MHz. We do not see a need to specify explicit restrictions. |
| Samsung | Y | Option 2 | Same handling as Proposal 2-3a. |
| NEC | Y | Option 2 |  |
| LGE | Y | Option 1 | But we share the view that we need further discussion with the two options. |
| MediaTek2 | Y | Option 2 | For the case when paging is *shared* between legacy UEs and eRedCap, we support transmission bandwidth of paging can be larger than 20MHz to reduce impact on legacy UEs. For the case when *dedicated* paging can be configured and transmitted to R18 eRedCap, we share a similar understanding with Nokia and Xiaomi that gNB first needs to be able to distinguish which paging messages are for R18 eRedCap UEs. This requires more discussion on the specification impact and real-deployment impact. Even if we can make such an agreement to ensure gNB gets this information from core NW, we are not sure this is a practical assumption in field when R18 eRedCap is being deployed.  |
| Sequans | Y |  | Agree with proposal at this point. |
| Intel | Y |  | Further discussion is necessary. Option 1 provide better link performance. Irrespectively of the selected option, at UE side, UE only has 5MHz capability for reception according to the WID.  |
| FL2 | Based on received responses, the following updated proposal can be considered, where the wording is aligned with the earlier agreement for SIB1.**High Priority Proposal 2-4b: For UE BB bandwidth reduction, for paging channel (PDSCH) ~~shared between~~ to Rel-18 RedCap UEs ~~and other types of UEs~~, down-select between the following options:*** **Option 1: Restrict the scheduling of paging channel to be within 5 MHz**
* **Option 2: Allow the scheduling of paging channel to be larger than 5 MHz (as in legacy operation)**
* **FFS: whether 5MHz is assumed to be physically contiguous**
 |
| OPPO | Y | Option 1 | We think narrow band paging would be sufficient. Also OK with updated in red. |
| Nordic  | Y |  | The fact is that for paging gNB should be aware of UE capas already. So tend to agree with Oppo that here narrow-band paging should not be an issue. |
| Nokia, NSB |  | Option 2 | We are OK with the FFS but we are still concern about the removal of the text on sharing, as this can imply we have separate paging to Rel-18 RedCap UE.First, we have not agreed that Rel-18 RedCap UE can be separately paged from other UEs. Second, if the paging channel is only to Rel-18 UE, then it doesn’t make sense to support Option 2.If it is the common understanding that proposal 2-4b covers the case where paging is shared with other UEs, then we are OK with the proposal. |
| FUTUREWEI | Y |  |  |
| Apple  |  | Opt.2 | First, the paging occasion is determined based on equation and known parameters, which is deterministic instances at UE side. In our opinion, Opt.2 means UE would use 20MHz ‘RF+BB’ for the paging occasion, including post-FFT buffering etc.  |
| Sharp | Y |  |  |
| Lenovo  | Y |  |  |

**FL1 High Priority Proposal 2-5a: For UE BB bandwidth reduction, for other broadcast PDSCH than SIB1 and paging (e.g., OSI, RAR), down-select between the following options:**

* **Option 1: Restrict the scheduling of broadcast PDSCH to be within 5 MHz**
* **Option 2: Allow the scheduling of broadcast PDSCH to be larger than 5 MHz (as in legacy operation)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Y/N** | **Preferred option,if any** | **Comments** |
| Huawei, Hisilicon | Y | Option 1 |  |
| Nordic  | N |  | OSI can follow SIB1, but RAR may need to be confined to 5MHz, so those two should not be coupled together  |
| MediaTek |  | Option 2 | Our view is that transmission bandwidth for all broadcast PDSCHs should be allowed up to 20MHz. UE BB bandwidth reduction does not restrict transmission bandwidth at gNB.  |
| FUTUREWEI |  |  | Both options can be discussed. We are okay to separate both. |
| Nokia, NSB | Y | Option 2 | Similar comment as in 2-4a.We do not see the need for the network to be aware of or have separate broadcast transmission for Rel-18 RedCap versus legacy UEs.  |
| Qualcomm | N |  | We share the same view with Nordic that SI and RAR needs to be discussed separately. Option 2 is preferred for OSI following SIB1. However, if separate early indication is supported for Rel-18 eRedCap UE, option 1 is preferred for RAR. |
| Lenovo | Y | Option 2 | It is not expected to introduce restrictions to legacy UEs.  |
| China Telecom | Y |  | Fine with the current proposal. It needs down-selection after further discussion. Maybe OSI and RAR can be considered separately if necessary. |
| CATT | Y |  | Same handling to agree Proposal 2-3a can be applied.Also OK to handle OSI with SIB1, leaving RAR here for further discussion. |
| vivo | Y | Option 2 | Share MTK’s views. In addition, similar as for SIB1 discussion, following FFS should be added:FFS: whether 5MHz is assumed to be physically contiguous |
| ZTE, Sanechips |  |  | Agree to discuss OSI and RAR separately.For OSI, repetition can be used for performance compensation. Therefore, option2 is preferred.For RAR, the performance loss may be acceptable since the TBS is small. And further discussion is needed. |
| DOCOMO |  |  | We are fine to discuss OSI and Msg2/4/B separately. |
| Spreadtrum |  |  | For OSI, we also think it can follow SIB1.For RAR, it is related to early indication. If early indication is supported and indicated, the RAR should be within 5 MHz, otherwise, the RAR can be larger than 5 MHz. |
| SONY | Y |  | Both options should be discussed. |
| CMCC | Y |  | Our first preference is not to restrict the bandwidth of shared broadcast PDSCH. However the performance of of other SIBs has not been evaluated, further discussion is needed. |
| Panasonic | Y |  | As the SIB1 agreement made on Monday, we would propose to add the FFS below:FFS: whether 5MHz is assumed to be physically contiguous |
| Xiaomi |  |  | We have the same comments as in **FL1 High Priority Proposal 2-4a.** |
| Ericsson | Y | Option 2 | Ok with Nordic’s and CATT’s suggestion that OSI can be handled in a similar way as SIB1. Also, note that there is on-demand transmission of OSI. So, if there is a mechanism for gNB to know that a Rel-18 RedCap UE is requesting OSI, it’s possible for gNB to schedule OSI within 5 MHz, without specifying any explicitly restrictions. |
| Samsung  | Y | Option 2 | Same handling as Proposal 2-3a. |
| NEC | Y | Option 2 | RAR would be FFS. |
| LGE | Y | Option 1 | But we share the view that we need further discussion with the two options. |
| Sequans | Y |  | Support proposal for later down-select.Fine to split OSI and RAR discussion. |
| Intel | Y |  | Both options can be discussed. Irrespectively of the selected option, at UE side, UE only has 5MHz capability for reception according to the WID. |
| FL2 | Based on received responses, the following proposals can be considered, where the wording is aligned with the earlier agreement for SIB1.**High Priority Proposal 2-5b:****For UE BB bandwidth reduction, for OSI (PDSCH) to Rel-18 RedCap UEs, down-select between the following options:*** **Option 1: Restrict the scheduling of OSI PDSCH to be within 5 MHz**
* **Option 2: Allow the scheduling of OSI PDSCH to be larger than 5 MHz (as in legacy operation)**
* **FFS: whether 5MHz is assumed to be physically contiguous**

**For UE BB bandwidth reduction, for RAR (PDSCH) to Rel-18 RedCap UEs, down-select between the following options:*** **Option 1: Restrict the scheduling of RAR PDSCH to be within 5 MHz**
* **Option 2: Allow the scheduling of RAR PDSCH to be larger than 5 MHz (as in legacy operation)**
* **FFS: whether 5MHz is assumed to be physically contiguous**
 |
| OPPO | Y | Option 1 | We think 5MHz band for other broadcast channel would be sufficient. Update is fine. |
| Nordic | Y |  | Option 2 for OSI, Option 1 for RAR |
| Nokia, NSB |  | Option 2 | Similar comment as in 2-4b. We are concern on the added text **“to Rel-18 RedCap UEs”** as this can imply we have separate OSI/RAR to Rel-18 RedCap UE.First, we have not agreed that Rel-18 RedCap UE can have separate OSI/RAR from other UEs. Second, if the OSI/RAR is only to Rel-18 UE, then it doesn’t make sense to support Option 2.If it is the common understanding that proposal 2-5b covers the case where OSI/RAR is shared with other UEs, then we are OK with the proposal. |
| FUTUREWEI | Y |  |  |
| Sharp | Y |  |  |
| Lenovo  | Y |  |  |

**FL1 High Priority Question 2-6a: For UE BB bandwidth reduction, can distributed resource allocation spanning more than 5 MHz be supported for unicast PDSCH/PUSCH? Please elaborate in the Comments field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | Clarification is suggested for any difference between the proposal and the PR3 defined in the TR. |
| Nordic  | N | Not OK with this proposal for PUSCH, PUSCH must be contiguous. For PDSCH PR3 would make sense, as R18 RedCap could be then multiplexed with R17 RedCap in frequency domain.  |
| MediaTek2 (updated with blue) | ~~N~~ Y for PDSCHN for PUSCH | We share a similar view with Nordic. For PDSCH, PR3 vs BW3 should be revisited in RAN1. For PUSCH, we support contiguous resource allocation confining to 5MHz, i.e. BW3. If UE complexity is not in fact reduced more with BW3 (than PR3), we think PR3 is a better choice for providing scheduling flexibility and frequency diversity gain.  |
| FUTUREWEI | N | We picked BW3 not PR3 and this is the main difference |
| Nokia, NSB | N | Our preference is BW3 so we do not support distributed resource allocation spanning more than 5 MHz. |
| Qualcomm | N | We prefer to keep resource allocation confined within 5MHz BW (BW3) as captured in WID. |
| Lenovo | N | It is not clear if 5MHz here is physically contiguous or not. But anyway, it is not supported to have unicast PDSCH/PUSCH spanning more than 5MHz. |
| China Telecom | N | We see no need to support distributed resource allocation spanning more than 5 MHz for unicast PDSCH/PUSCH. |
| Sharp | N |  |
| CATT |  | PUSCH does not have post-FFT buffering issue, so the cost does not care too much about whether the resource allocation is continuous or not. Again, remind that current NR already supports CP-OFDM (non-continuous PRB allocation) in PUSCH…But for PDSCH, spanning more than 5 MHz are likely to increase post-FFT buffering than BW3. That’s why BW3 is initially adopted when WID is written.It is naturally preferred to have unified solution for PDSCH and PUSCH. Consequently, ‘distributed resource allocation spanning more than 5 MHz’ is not preferred for both PDSCH and PUSCH. HOWEVER, frequency hopping interval of PUSCH should be allowed to expand 5 MHz, where each hop is within 5 MHz. |
| vivo | Y | Although the WID text for BB bandwidth reduction uses BW3 wording, as discussed in RAN#97, the real definition needs to be figured out in RAN1. So PR3 is still one candidate. About companies’ concern on non-contiguous resource allocation for PUSCH, we think even if PR3 is supported for both DL and UL, it does not mean UE support the non-contiguous PUSCH resource allocation. It depends on UE capability. Currently no RAN4 UE features support the non-contiguous PUSCH resource allocation, even almostContiguousCP-OFDM-UL is one optional UE feature. But just from the specification perspective, we think non-contiguous resource allocation for PUSCH can be supported.  |
| ZTE, Sanechips | N | We do see the need to support distributed resource allocation spanning more than 5 MHz.  |
| DOCOMO | N | To ensure the complexity reduction gain, we support the resource allocation confined within 5MHz for both PDSCH and PUSCH. |
| Spreadtrum | Y for PDSCHN for PUSCH | For PDSCH, we think both PR3 and BW3 are acceptable, since the differences are quite small. In addition, from resource allocation point of view, BW3 is actually a subset of PR3. If we cannot make consensus on further limitation, PR3 can be a baseline to make progress. For PUSCH, contiguous resource allocation is preferred. |
| SONY | N | We understood that the WID specified BW3 support, not PR3.  |
| CMCC | N | Both unicast PDSCH and PUSCH is within 5MHz, e.g. BW3. distributed resource allocation is possible within 5MHz. |
| Panasonic |  | The WID does not clarify which BW3 or PR3 is adopted. There is no sentence such as “The resource allocation spans a bandwidth of maximum 5 MHz” or “The resource allocation spans a bandwidth of maximum 20 MHz (maximum UE channel bandwidth)” It should be revisited in RAN1.At least for PDSCH, distributed resource allocation spanning more than 5 MHz (PR3) should be allowed for better scheduling flexibility. Even if BW3 is adopted, the additional complexity reduction is not so significant although it requires the additional techniques discussed in 2-9a or 2-10a.For PUSCH, it should be contiguous within 5MHz as said by Nordic. |
| Xiaomi |  | Share the same view as Huawei that further clarification is needed.Besides, another issue needs to be considered is whether frequency hopping spanning more than 5MHz is supported for PUSCH with contiguous resources allocation. From our point of view, frequency hopping spanning more than 5MHz can be achieved without any additional efforts to the eRedCap UE’s implementation. So, frequency hopping shouldn’t be limited within 5MHz. |
| Ericsson |  | Similar view as Nordic. Distributed allocation of PDSCH allows more scheduling flexibility and frequency diversity/scheduling gain, although it (very) slightly reduces the cost saving gain. PUSCH is typically contiguous. For non-contiguous PUSCH, the support of *almost contiguous UL CP-OFDM* (Feature 2-7 defined in TR 38.822) or *resource allocation Type 0 for PUSCH* (Feature 5-2 defined in TR 38.822) features are optional with capability signaling. |
| Samsung | N | Distributed resource allocation spanning more than 5 MHz couldn’t bring additional gain on complexity reduction. Frequency selective gain from spanning more than 5MHz can be achieved by frequency hopping of 5MHz. |
| LGE | N | Our understanding is that we specify BW3, and revisit PR3 in the next RAN plenary meeting. While we are specifying BW3, we prefer to avoid complicating things by mixing up BW3 and PR3. |
| Sequans |  | N for PUSCH.For PDSCH, we’d like to understand better the tradeoff between post-FFT buffering complexity and scheduling gain |
| Intel |  | We prefer to allow distributed FDRA in 20MHz subjected to a limit of 25 or 11 PRBs. However, if majority companies want to limit to continuous 5MHz, we are fine to go with it.  |
| FL2 | Based on received responses, the following proposal can be considered. The PDSCH case can be revisited once other aspects (e.g., resource allocation) have progressed further.**High Priority Proposal 2-6b: For UE BB bandwidth reduction, distributed resource allocation spanning more than 5 MHz is not supported for PUSCH.** |
| OPPO | Y | We see the clarification for any difference between the proposal and the PR3 defined in the TR needed as suggest by Huawei. But since FL2 capture majority, the updated direction is Ok.But more useful conclusion would mean the RBs for PUSCH is within 5MHz physical bandwidth.  |
| Nordic | Y | This is a baby step forward.  |
| Nokia, NSB | Y | We are OK with this proposal. |
| FUTUREWEI | Y with comment | First, it is unclear whether intra-slot frequency for Msg3 is allowed. Second, we suggest a clarification**For UE BB bandwidth reduction, distributed resource allocation spanning more than 5 MHz within a slot is not supported for PUSCH.** |
| Apple  | Y | Prefer the FL proposal.  |
| Sharp | Y | We are OK with this proposal. |
| Lenovo | Y | To avoid any misunderstanding, suggest to revise to “**For UE BB bandwidth reduction, ~~distributed~~ PUSCH resource allocation spanning more than 5 MHz is not supported ~~for PUSCH~~.”.** And maybe good to add “**FFS: whether 5MHz is assumed to be physically contiguous”** |

**Aspects related to impacts on broadcast channels**

Some contributions [15, 30] express that it should be possible to share broadcast PDSCH transmissions (e.g., SIB, OSI, RAR, Paging) between Rel-18 RedCap UEs and other UEs, and a few contributions [22, 29, 35] indicate that it is not necessary to specify coverage enhancements for channels that already support multiple transmissions (e.g., SIB1), since the UE implementation can rely on combination of the transmissions.

Some contributions [18, 24, 32] express that further discussion is needed regarding whether these broadcast PDSCH transmissions can be shared or may need to be separate. Some contributions [10, 14, 15, 20, 24, 33] propose to study whether further optimizations/enhancements for broadcast PDSCH are needed. One contribution [11] proposes to either restrict the bandwidth of the resource allocation of broadcast PDSCH transmission to 5 MHz or clarify the UE behavior when this bandwidth is larger than 5 MHz.

**FL1 High Priority Question 2-7a: For UE BB bandwidth reduction, considering the conclusions in TR 38.865 clause 8.2.4, should any enhancements or restrictions be specified to compensate for SIB1 link performance loss?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | Potential enhancement for SIB1 can be studied. But it seems too early to state that specification impact is needed.  |
| Nordic  |  | We could leave it up to implementation |
| FUTUREWEI | N | Compensation for SIB1 performance was not part of the WID |
| Nokia, NSB |  | We would like to study further potential enhancements for broadcast channels. |
| Qualcomm |  | We suggest discussing potential enhancements for broadcast channels.  |
| Lenovo |  | SIB1 performance can be improved by UE implementation. There is no strong motivation to specify enhancements.  |
| China Telecom |  | Potential solutions to compensate SIB1 link performance loss can be studied if it is consensus. |
| Sharp | Y | The performance degradation in TR 38.865 is mainly for cases where allocated bandwidth of SIB is larger than 5MHz. if the scheduling of SIB1/OSI for eRedCap is allowed to be larger than 5 MHz, further enhancement can be considered. |
| CATT |  | ‘Decoding enhancements’ can be up to UE implementation.‘Restrictions to be specified’ is not preferred by us currently. |
| Vivo |  | Whether SIB1 has link performance loss depends on the interpretation of the 5 MHz BB bandwidth for SIB1 buffer/reception, process in case the resource allocation for SIB1 exceeds 5MHz.  |
| ZTE, Sanechips |  | For 5MHz buffer capability, SIB1 performance can be be improved.by soft combining. However, the UE may need to know which 5MHz PDSCH data should be combined before combing decoding.For 20MHz buffer capability, SIB1 performance can be be improved.by implementation. |
| DOCOMO |  | We are supportive to discuss potential enhancements for SIB1 link performance compensation. |
| Spreadtrum |  | We are open, but it seems too early to conclude this. |
| SONY |  | Performance enhancement can probably be left to implementation. We are also OK to consider enhancements / restrictions to compensate for SIB1 performance loss. |
| CMCC | N | Soft combining is already supported and it is better than the bottleneck channel of R17 RedCap. |
| Panasonic |  | It should be up to UE implementation. |
| Xiaomi | N | We can leave it to UE implementation by HARQ combination without reducing the cost of post-FFT buffering. |
| Ericsson | N | We do not see a need to specify any enhancements/restrictions for SIB1. As shown in our contribution ([R1-2210283](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210283.zip)), Rel-18 RedCap UEs can achieve the same SIB1 link performance as Rel-17 RedCap UEs by soft-combining multiple SIB1 transmissions within the 160 ms TTI.  |
| Samsung | N | Compensation for SIB1 performance loss can be up to UE implementation. |
| NEC | N | In our opinion, RAN1 should strive for no enhancements nor specification impacts by utilizing existing features, e.g. relying on retransmissions. |
| LGE | N | Out of the study phase, no recommendation was made on the link performance enhancement because there was no outstanding coverage issue for the cases under study. In our view, there is no need to further study on this aspect. |
| MediaTek |  | For initial access/idle/inactive mode, enhancements/restrictions may not be needed. For connected mode, RAN1 may need to discuss whether eRedCap UEs are required to decode SI-RNTI PDSCH simultaneously with C-RNTI PDSCH in FR1.  |
| Intel |  | Potential enhancement to SIB1 can be studied since we identify more than 10dB loss without any special handling.  |
| FL2 | Based on received responses, it seems that SIB1 performance needs to be better understood before it can be decided whether any enhancements or restrictions are needed. |
| OPPO | Y | Agree FL2 make it on-hold. |
| Nordic  | N | We should have some concrete action. Is the intention here to have new round of simulations? |

**FL1 Medium Priority Question 2-8a: For UE BB bandwidth reduction, should any enhancements or restrictions be specified to compensate for link performance loss for other broadcast PDSCH transmissions than SIB1?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

**Scheduling optimizations for reducing post-FFT buffer complexity**

Several contributions [14, 17, 20, 21, 23, 28, 35] propose to consider whether the frequency location for PDSCH and/or PUSCH within the BWP can be indicated by semi-static configuration of the UE. A few contributions [14, 24, 29] propose to study solutions to facilitate post-FFT buffer reduction. For example, one contribution [23] proposes to consider DCI-based PRB subset switching to maintain frequency diversity, whereas one contribution [15] expresses that the UE can be dynamically allocated any frequency location within the BWP without any optimization.

**FL1 High Priority Proposal 2-9a: For UE BB bandwidth reduction, it is FFS whether/how to support semi-static indication of frequency location for PDSCH within the DL BWP for reducing the post-FFT buffer complexity.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| MediaTek |  | If BW3 (i.e. PDSCH resource allocation confining within 5MHz) is to be agreed, our view is that semi-static indication or pre-defined in spec should be supported. Considering it is the first meeting in WI, we have the following way-forward proposal:* **Proposal:** If BW3 is agreed, down-select from the following options for eRedCap UEs to determine which 5MHz “sub-band” is allocated for a unicast PDSCH
	+ Option 1: eRedCap UE knows which 5MHz “sub-band” is allocated for a unicast PDSCH before it decodes corresponding PDCCH
		- Option 1a: semi-static indication by RRC
		- Option 1b: pre-defined in specification
	+ Option 2: same slot unicast PDSCH scheduling, i.e. K0=0, is not supported by eRedCap UE.

Our understanding is that the 1% more complexity reduction that BW3 provided mainly was resulted from the assumption that UE had known which 5MHz “sub-band” would be scheduled beforehand, and post-FFT buffer size and DL receiver block reached more complexity reduction with BW3 than with PR3. If BW3 cannot reach more complexity reduction than PR3, we don’t see why to support a the more restricted BW3.  |
| FUTUREWEI |  | Both semi-static indication and cross-slot scheduling (proposal 2-10a) are approaches to reduce post-FFT buffer complexity. Both approaches have benefits and limitations. For semi-static indication, the network can use same-slot scheduling but the network may be restricted to using certain resources. From the UE side, the post-FFT buffer complexity is higher than with cross-slot scheduling as the UE must process both PDCCH and PDSCH (within a known region) in the same slot. We can consider “whether/how to support semi-static indication of frequency location” moving forward. |
| Nokia, NSB | N | In our view we do not see the need to support semi-static indication of frequency location for PDSCH within the DL BWP. In our view the potential complexity reduction would be small. However, this would restrict scheduler flexibility / increase complexity and also require considerable standardization effort. |
| Qualcomm | N | At least for SIB1 PDSCH, a UE has to support dynamic indication of frequency location if SIB1 PDSCH is shared between Rel-18 UEs and other type of UEs. Therefore, UE anyway has to support post-FFT buffering for 20MHz BWP until the DCI is correctly decoded. Then we do not understand how the semi-static indication of frequency location can reduce the post-FFT buffering complexity. Also semi-static indication of PDSCH frequency location limits the scheduling flexibility. We prefer to have dynamic indication of the actual resources inside the configured BWP. |
| Lenovo | Y | Semi-static indication of frequency allocation for PDSCH has benefits including post-FFT buffer complexity reduction and potential DCI size reduction.  |
| China Telecom |  | The necessity and benefits should be studied and evaluated before making the final decision. |
| Sharp | Y | We support the proposal. It is beneficial for UE to reduce the size of the post-fft buffer. |
| CATT | Y | Agree with MTK and FUTUREWEI.If optimization to reduce post-FFT data buffering is NOT further considered, we need to revisit why not adopt PR3 instead of BW3. |
| Vivo |  | We wondered how this solution works for Rel-18 RedCap UEs in RRC\_idle/inactive mode. How does RRC\_idle/inactive RedCap UEs know the frequency location for PDSCH? |
| ZTE, Sanechips |  | In connected mode, semi-static indication of frequency location for PDSCH can be considered.After receiving SIB1, semi-static indication via SIB1 is also feasible for other broadcast channels. For SIB1, we may need to further discuss, since semi-static indication is not available. Additionally, dynamic indication or other solutions should not be precluded currently. |
| DOCOMO |  | For reducing the post-FFT data buffer complexity, we think at least the following four options can be considered for PDSCH reception;* Opt.1: semi-static FDRA/pre-defined FDRA
* Opt.2: cross-slot scheduling
* Opt.3: soft-combining of multiple reception
* Opt.4: puncturing of one-shot reception

Therefore, semi-static indication of frequency location can be one potential technique for post-FFT data buffering BW reduction but we think other techniques also should be considered. In our understanding, if the PDSCH resources are shared between Rel-18 RedCap and legacy UEs, e.g., for broadcast PDSCH, Opt.1/2 cannot be supported since these operations are not supported for legacy UEs. Thus, how to reduce post-FFT buffer complexity can be discussed separately for broadcast and unicast PDSCH. |
| Spreadtrum | Yes with comments | For SIB1, it seems unlikely to reduce the post-FFT buffering complexity. But in connected mode, semi-static indication of frequency location maybe benefit. Considering the payload size for UE-specific PDSCH in connected mode is larger than SIB1, there may be opportunities to lower the total post-FFT buffering, in addition, semi-static indication is benefit to the power consumption. We prefer to further check and study it. |
| SONY | Y | Semi-static indication further reduces post-FFT buffer complexity.We are OK with the proposal from Mediatek, but don’t necessarily agree with all of their argumentation. |
| CMCC | N | For broadcast PDSCH, whether to restrict of the bandwidth is still open, if option 2 of 2-3a to 2-5a is chosen, dynamic indication is supported for these channel.For unicast PDSCH, if the PDSCH span does not exceed 5MHz, the following three options can be studied.* Option 1: dynamic indication of PDSCH within 20MHz, no post FFT data buffer benefit but flexible scheduling to maintain frequency diversity gain.
* Option 2: semi-static indication of frequency location of PDSCH. There is post FFT data buffer benefit, but the frequency diversity gain loss.
* Option 3: dynamic indication of RRC configured sub-BWPs or RB subsets. This can achieve the benefit of option 1 and option 2.

Since this is the first meeting of WI, we prefer to keep design open.So we propose to modify the proposal to,**For UE BB bandwidth reduction, it is FFS whether/how to support semi-static indication or dynamic indication of predefined frequency locations for PDSCH within the DL BWP for reducing the post-FFT buffer complexity.**  |
| Panasonic | Y | The discussion related to 2-4a/2-5a/2-6a should be stable before discussing whether to support this indication. |
| Xiaomi | N | We think it is not necessary to semi-static configure the bandwidth location for PDSCH if post-FFT buffering for 20MHz BW is supported by eRedCap UEs.  |
| Ericsson |  | This can be discussed after the outcome of the discussion in Q2-6a. If a PR3-like solution is specified, semi-static indication would not have any benefits in terms of post-FFT buffer size reduction. |
| Samsung | Y | We are fine for the proposal. It is beneficial for complexity reduction of post-FFT data buffering. |
| NEC | N | Considering almost comparable complexity reduction gain of BW3 and PR3, complexity reduction gain by post-FFT data buffering would be moderate. Therefore, in our opinion, from scheduling flexibility and standardization efforts perspective, legacy dynamic resource allocation by DCI across 20 MHz BW at maximum would be preferable instead of introducing semi-static resource allocation. |
| LGE | Y | The current proposal covers only the semi-static approach which is okay per say. In addition, we would like to also consider other approaches, e.g., predefined in the spec, cross-slot scheduling. As a whole, we support the techniques to reduce post-FFT buffer. |
| Intel | Y | We share similar view with Lenovo that semi-static indication of frequency allocation for PDSCH is beneficial for reduced post-FFT buffer and reduced DCI size.  |
| Nordic  | N | Since reduction of post-FFT buffer advantage has been providing less than 1% of benefit. |
| FL2 | Based on the responses to Proposals 2-9a and 2-10a, the following proposal can be considered.**High Priority Proposal 2-9b: For UE BB bandwidth reduction, it is FFS whether/how to support ~~semi-static indication of frequency location for PDSCH within the DL BWP for~~ reducing the post-FFT buffer complexity.** |
| OPPO |  | We see lot of justification needed for introducing this.And also it will greatly restrict the scheduling flexibly, we need consider the cost of it.We also don’t see a general FFS is needed in FL2. |
| Nordic  |  | Cost is high in terms of restriction and specification effort, benefit close to zero. Moreover, UE capability to buffer whole slot is the best solution for sharing broadcast with legacy UEs. |
| Nokia, NSB | N | In the SI phase, the additional complexity reduction from reducing post-FFT buffering was found to be quite small. However, the standardization effort, scheduling restriction, and implementation effort is likely to be considerable. Therefore, we do not see the need to further study this. |
| FUTUREWEI | N | Companies mentioned several possible approaches to reduce post-FFT buffer complexity. By making all approaches FFS, then the UE BB bandwidth reduction technique is PR3 if no approach is agreed. It is contrary to the selection of BW3 at RAN for the WID ... we can refine the definition but should not define BW3 to be PR3. |
| Lenovo | Y |  |

Some contributions [14, 16, 17, 26] bring up the possibility to use cross-slot scheduling (rather than same-slot scheduling) for unicast and/or broadcast for the purpose of facilitating reduction of the post-FFT data buffering.

**FL1 High Priority Proposal 2-10a: For UE BB bandwidth reduction, it is FFS whether/how to support cross-slot scheduling for PDSCH (for unicast and/or broadcast) for reducing the post-FFT buffer complexity.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| MediaTek |  | As commented in the above, if BW3 is agreed, we think UE should be able to know which 5MHz “sub-band” is allocated for a unicast PDSCH **before** it decodes the corresponding PDCCH, i.e. we support Option 1 (1a or 1b) in our proposal in the comments to FL1 High Priority Proposal 2-9a in the above. However, we are open to discuss cross-slot scheduling for now.  |
| FUTUREWEI |  | As we commented above, cross-slot scheduling allows processing of PDCCH and PDSCH in separate slots, lowers post-FFT buffer complexity, and provides the network flexibility to manage which resources to schedule. While current specifications indicate that broadcast PDSCH need same-slot scheduling, there are techniques to manage same slot-scheduling and should be discussed. We support “whether/how to support cross-slot scheduling” moving forward. |
| Nokia, NSB | N | We do not want to mandate cross-slot scheduling as this would restrict scheduler flexibility / increase complexity and also require considerable standardization effort. In our view the potential complexity reduction would be small. |
| Qualcomm |  | Cross-slot scheduling is already supported for unicast PDSCH in current spec so we do not need to discuss unicast PDSCH here. Then the proposal would be only for broadcast PDSCH with default TDRA table. We do not have preferences on supporting cross-slot scheduling for broadcast PDSCH as we have to consider the coexistence scenario that SIB1 PDSCH shared between Rel-18 UEs and other type of UEs.  |
| Lenovo |  | Similar view with Nokia, we don’t want to mandate cross-slot scheduling. |
| China Telecom |  | The same view as Proposal 2-9a. The necessity and benefits should be studied and evaluated before making the final decision. |
| Sharp |  | eRedCap UE can reuse R16 cross-slot scheduling for unicast PDSCH. For broadcast PDSCH, cross-slot scheduling can be discussed separately for SIB1/OSI/msg2/msg4/paging PDSCH. |
| CATT | Y | Same comments above. Agree with MTK and FUTUREWEI.If optimization to reduce post-FFT data buffering is NOT further considered, we need to revisit why not adopt PR3 instead of BW3. |
| Vivo |  | Cross-slot scheduling for unicast data is already supported by current specification, so we do not need to discuss it for unicast data. But for broadcast PDSCH, cross-slot scheduling is not supported by current specification, increases NW scheduler complexity and seems not within the WID scope.  |
| ZTE, Sanechips |  | For SIB1, only default A is supported and cross slot scheduling is not supported in default A. Considering SIB1 may be shared with Rel-18 RedCap UE and other types of UE, cross-slot scheduling for SIB1 should not be supported.For unicast, cross-slot scheduling is already supported as a optional feature. To reduce the post-FFT buffer complexity, we may need to only support the cross-slot scheduling feature. However, from our understanding, same slot scheduling is mandatory due to SIB1 receiving, therefore, it is not possible to only support the cross slot scheduling. Moreover, same slot scheduling should be supported for lower latency and scheduling efficiency. Therefore, default cross-slot scheduling should not be a candidate solution for reducing the post-FFT buffer complexity. |
| DOCOMO |  | Similar comment as 2-9a. cross-slot scheduling can be one potential solution to reduce post-FFT buffer complexity, however, for broadcast PDSCH which is shared between Rel-18 RedCap and legacy UEs, it cannot be supported. |
| Spreadtrum | Yes with comments | In our understanding, the current cross-slot scheduling is gNB controlled (disable and enable), but the cross-slot scheduling discussed here can be a kind of default capability if the UE is R18 RedCap.We are open to further check the differences and the possible benefits of cross-slot scheduling. |
| SONY |  | We assume that cross-slot scheduling would be supported for unicast PDSCH anyway. Isn’t the issue about whether we support same-slot scheduling for unicast PDSCH?For broadcast PDSCH, we are OK to consider whether anything needs to be done to support broadcast PDSCH.  |
| CMCC |  | For unicast PDSCH, as mentioned by Qualcomm, cross slot scheduling is already supported by R16 UE power saving, may be we need to discuss is whether to introduce the cross-slot scheduling feature for R18 RedCap UEs.For multicast PDSCH, we do not think cross slot scheduling is needed, if introduced, some common channels such as SIB1 can not be shared. |
| Panasonic | Y | The discussion related to 2-4a/2-5a/2-6a should be stable before discussing whether to mandate cross-slot scheduling. |
| Xiaomi | N | Similar view with Nokia. |
| Ericsson | N | We are not fine with mandating cross-slot scheduling for all cases. Furthermore, as Qualcomm has commented, it is already possible for the gNB to configure cross-slot scheduling for unicast PDSCH in connected mode (for power saving purposes).  |
| Samsung |  | For unicast PDSCH, cross-slot scheduling has been supported. For broadcast PDSCH, it can depend on channel type. For SIB1/Paging, any enhancement on scheduling is not needed considering sharing the same SIB1/Paging with legacy UE. For Msg2/Msg4/MsgB, scheduling related enhancement can be considered if early capability indication is supported. |
| NEC | N | Share view with Nokia. |
| LGE | Y | The current proposal covers only the cross-slot scheduling aspect which is okay per say. In addition, we would like to also consider other approaches, e.g., semi-static and predefined in the spec. From the two proposals above, 2-9a and 2-10a, we wonder if the “predefined in the spec” approach is also covered or not. If not covered, we would like to include it as an option to further consider. As a whole, we support the techniques to reduce post-FFT buffer. |
| Intel |  | Due to the quite limited available features for complexity reduction, we think it is beneficial to apply cross-slot scheduling for unicast PDSCH and for broadcast PDSCH |
| Nordic  | Y | Specification impact could be limited if cross-slot applies to unicast only. |
| FL2 | See Proposal 2-9b. |
| OPPO |  | After all this features, we realized it is difficult to really saving by those cross-slot scheduling, if we have normal SIB processing timeline which including same-slot, the UE will have the ability, then only cross slot for unicast data would not save the over all processing capability.Still, same question for Proposal 2-9b. |
| Apple  |  | First, the proposal here is to mandate the ‘cross-slot’ scheduling for PDSCH for eRedcap UE. The post-FFT buffer can be reduced assuming UE can decode the PDCCH within a slot (very typical case) and then only extract the REs used for scheduled PDSCH for HARQ buffer. Although the ‘cross-slot’ has been supported for unicast PDSCH since Rel-15, it is up to gNB scheduler to use ‘same slot’ or ‘cross-slot’ for a given PDSCH scheduling. Due to this uncertainty, a UE has to store 20MHz post-FFT samples before DCI decoding completion, which creates additional cost. If ‘cross-slot’ scheduling is mandated for unicast PDSCH and known at UE side, UE can always customize buffer size based on up to 5MHz BB and therefore cost is reduced. On the other hand, we also agree that depending on whether a shared post-FFT buffer is used for SIB and unicast PDSCH reception, there may or may not have post-FFT buffering benefit by cross-slot scheduling if SIB anyway is allowed to be larger than 5MHz BB.  |

**Frequency-domain resource allocation (FDRA) optimization**

A few contributions [19, 33, 35] suggest that FDRA optimization/enhancement can be considered. One contribution [16] proposes to consider dynamic indication of a 5-MHz region, where the FDRA is defined within this region. One contribution [29] proposes that FDRA for unicast can be based on 5-MHz sub-bands to save DCI overhead. One contribution [24] proposes to discuss potential reuse of spare bits from the FDRA field in the RAR UL grant.

**FL1 Medium Priority Question 2-11a: For UE BB bandwidth reduction, should any kind of FDRA optimization be considered for further study? Please elaborate your response in the Comments field.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

**Other aspects of UE BB bandwidth reduction**

* The same resources within 5 MHz and [≤10 MHz] are used for the duration of the slot [8].
* PUCCH and SRS are restricted to 5MHz, at least when PUSCH is present and FFS when PUSCH is not present; FFS for the 5 MHz restriction of RACH [8].
* Intra-slot or inter-slot frequency hopping within bandwidth larger than 5MHz can be supported for PUSCH (including Msg3 PUSCH) while keeping the 5 MHz maximum BW of each hop [9].
* Simultaneous reception of PDSCH (limited to 5MHz in baseband) and SSB/PDCCH/CSI-RS within the BWP is supported for BWP of up to 20 MHz; simultaneous reception of two PDSCH transmissions (e.g., unicast and broadcast) is supported. FFS UE behavior when total frequency allocation is larger than 5 MHz; simultaneous transmission of PUSCH (limited to 5MHz in baseband) and PUCCH within the BWP is supported for BWP of up to 20 MHz [15].
* The UE behavior for the reception of multiple simultaneous PDSCHs needs to be specified for Rel-18 RedCap UEs [20].
* Decide whether a Rel-18 RedCap UE can process two broadcast PDSCHs or one broadcast PDSCH plus one unicast PDSCH are FDM multiplexed in a slot [16].

# 3 UE peak data rate reduction

According to the WID [1], it should be checked in RAN#98-e whether the UE peak data rate reduction is limited to UEs with UE BB bandwidth reduction only or whether it can be a standalone feature.

* Several contributions [9, 10, 15, 16, 21, 24, 19, 20, 22, 30, 34] express that UE peak data rate reduction should only be supported as an add-on feature to the UE BB bandwidth reduction feature and not as a standalone feature, whereas other contributions [11, 13, 14, 17, 25, 27, 33] express that UE peak data rate reduction should be supported as a standalone feature.
* Some contributions [9, 10, 16, 21, 35] express that specifying a standalone UE peak data rate reduction feature would lead to introduction of multiple new UE types and/or fragment the ecosystem, whereas one contribution [33] expresses that it would not introduce additional UE types, would not have RAN1 specification impact, would facilitate early implementations, and would be beneficial for dual-mode LTE-NR devices, and finally one contribution [27] expresses that it might in fact improve the economies of scale.
* A couple of contributions [26, 35] conclude that the combination of UE BB bandwidth reduction and UE peak data rate reduction (e.g., to *vLayers*·*Qm*·*f* ≥1) would not meet the target of 10 Mbps peak rate indicated in the justification part of the WID [1]. A few contributions [11, 28] propose that the constraint (*vLayers*·*Qm*·*f* ≥ 4) is not relaxed at all. One contribution [27] expresses that the relaxed peak rate constraint shall be chosen such that the peak data is not less than 10 Mbps in downlink and 5 Mbps in uplink (as for LTE Cat-1).
* One contribution [10] expresses that UE peak data rate reduction can be considered as a standalone feature for FR2, whereas another contribution [8] expresses that this would not be in the Rel-18 WI scope.

Regarding the relaxation of the constraint (*vLayers*·*Qm*·*f* ≥ 4) for UE peak data rate reduction, the WID [1] suggests that it can be, e.g., 1 instead of 4 and that the parameters (*vLayers*, *Qm*, *f*) can be as in Rel-17 RedCap. Many contributions [9, 10, 11, 13, 14, 16, 17, 22, 25, 27, 30, 32, 33, 34] discuss what the relaxed value ought to be. As mentioned above, some contributions observe that the resulting peak rate will be much lower than 10 Mbps if the UE BB bandwidth reduction feature is combined with the UE peak data rate feature with a relaxed constraint of 1 instead of 4, and some of them suggest that a relaxed constraint of around 3 would be more suitable for meeting the targeted peak rate of 10 Mbps.

Based on the above considerations, the following proposal can be considered, where the square brackets indicate that the values are working assumptions which will be revisited.

**FL1 High Priority Proposal 3-1a:**

* **If UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [3].**
* **If UE peak data rate reduction is supported as a standalone feature,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | OK for the first bullet. However, if two values are supported in the spec, it is unclear how one UE type of Rel-18 RedCap can be achieved considering additionally early identification is required. Therefore, we suggest to put the second bullet as FFS. |
| Nordic  | N | We should have single value agreed for R18 RedCap as WID states* + UE peak data rate reduction
		- Relaxation of the constraint (*vLayers*·*Qm*·*f* ≥ 4) for peak data rate reduction
		- The relaxed constraint is, e.g., 1 (instead of 4).
		- The parameters (*vLayers*, *Qm*, *f*) can be as in Rel-17 RedCap.
 |
| FUTUREWEI |  | We can accept with the “If”, but given the SI conclusion the “add on” is both not so much in question and also falls more clearly in a single UE type. So from that perspective, also ok to just state that standalone is FFS |
| Nokia, NSB | N | Agree with Nordic that we should only have one value. Our preference is to have UE peak data rate reduction as an add-on to UE BB bandwidth reduction as recommended by RAN1 in the TR.  |
| Qualcomm | N | We are fine with the proposal for standalone case. However, for the add-on case, *vLayers*·*Qm*·*f* = 3 does not meet 10Mbps peak rate with 12 PRB for 30KHz SCS so we prefer ***vLayers*·*Qm*·*f* ≥ 3.2.** **Alternatively**, we can also do like:* **If UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ X.**
	+ **X is the smallest possible value which meets 10Mbps for PDSCH/PUSCH for 15/30KHz SCS.**
* **If UE peak data rate reduction is supported as a standalone feature,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**
 |
| CATT | Y | Maybe we can add a note to move forward:Note: One of the branches may be deleted/invalid, depending on whether peak data rate reduction is supported as add-on or standalone or both, which is separately discussed.  |
| vivo |  | For the first bullet, if UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction, to relax the constraint from 4 to 3, from our understanding, the cost saving is quite limited. It seems not meaningful to further relax the constraint. But if relax the constraint from 4 to 1, the DL/UL peak data rate will become 2.94Mbps/3.15Mbps for 30KHz SCS. From achieved peak data rate perspective, it can be viewed as a different eRedCap type from the one supporting 10Mbps target data rate.We are fine with the second bullet. But it does not mean UE peak data rate reduction is supported as a standalone feature, whether to support it should be decided in Dec. RAN plenary meeting.  |
| ZTE, Sanechips |  | Similar view as Huawei, FUTUREWEI, and Nokia, we can keep the first bullet for PR1 as add on tech. And for the standalone, keep it as FFS.For the relaxed constrain value, on one hand, PR1 based on BW3 can reduce the peak data rate to 10Mbps from 13Mbps, and provide quite limited complexity reduction, e.g., less than 0.5%. on the other hand, not all the UEs should target at the 10Mbps peak data rate. For some low end UEs, the requirement for the peak data rate is lower. Therefore, the constrain value can be further relaxed, e.g., 2, and the SIB transmission should be guaranteed based on the constrain. |
| DOCOMO |  | We share the similar view as HW, FUTUREWEI, Nokia and ZTE to put FFS on the second bullet. The exact value of relaxed constraints can be discussed further based on the number of RBs for 5MHz (i.e., discussion for Proposal 2-1a).We also support ZTE that the constraint can be further relaxed to lower the peak rate as long as the TBS/payload size for broadcast PDSCH, e.g, SIB1, can be supported. |
| Spreadtrum |  | For the add-on part, we also think the value can be 2.* If the allowed TBS within a TTI is around 3000bits, the SIB/paging reception in idle mode and the RACH procedure will not be impacted (no additional impacts were expected compared to 5MHz BB reduction only). Further peak rate reduction (smaller than 10Mbps) is benefit to the memory/buffer requirements. As 3000bits corresponding to 6Mbps (30KHz), then the constraint can be relaxed from 4 to 2 for Rel-18 RedCap UEs with 5MHz BB bandwidth.

For standalone part, we share the similar view as HW, FUTUREWEI, Nokia, ZTE and DOCOMO, e.g., to state that standalone is FFS for now. |
| SONY | Y | At this stage, we should consider both the “standalone” and “add-on” cases. The values of “[3]” for add-on and “[1]” for standalone seem reasonable. The values can be tweaked as the WI progresses. |
| CMCC |  | We propose PR1 is an add on feature rather than a standalone. Considering the limited cost reduction gain and one UE type limit. FFS for the second bullet is ok. |
| Panasonic | Y |  |
| Xiaomi |  | We suggest to modify the proposal as follows:**For UE peak data rate reduction, down-select from the following two situations:** * **Situation 1: UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [3].**
* **Situation 2: UE peak data rate reduction is supported as a standalone feature,**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**

Based on above, situation 1 is more preferred by us.  |
| Ericsson | N | For the add-on case, we agree with Qualcomm that a value of 3 would not meet the 10 Mbps peak data rate requirement (even for FDD). One could consider a value of 3.2, however, it would not lead to any meaningful complexity reduction on top of BB bandwidth reduction. For the standalone case, we have concerns on its implications on UE type definition, early indication, and market fragmentation.Our preference would be to simply conclude that there is no need to introduce UE peak rate reduction in Rel-18 from RAN1 perspective.  |
| Samsung |  | Firstly, we should discuss whether to support PR3 as an add-on and/or standalone feature. Then, the relaxed value of constraint ***vLayers*·*Qm*·*f*** can be further discussed. We prefer to support PR3 as an add-on feature. |
| NEC |  | For the second bullet on SA-PR1, we prefer to discuss whether to support SA-PR1 first. We are also OK to put FFS to the second bullet. |
| LGE | N | We share the same view with Nokia. |
| MediaTek |  | We are fine with the proposal though further relaxation to [3] under first bullet may not seem very attractive in terms of UE’s complexity reduction.A question for clarification: If this proposal is agreed, does it mean PR1 is supported both as a standalone feature and an add-on feature in R18? Or standalone vs add-on is a separate discussion?  |
| Sequans | Y | We are fine with current proposal. Also fine to have standalone bullet as FFS. |
| Intel |  | We are supportive to the proposal. It would be helpful to clarify RAN1 is not intended to support both ‘add-on’ and ‘standalone’, and we prefer ‘add-on’ option.  |
| Nordic | Follow up  |

|  |  |
| --- | --- |
| 38.306 constraint value | Max TBS /per ms (15kHz SCS, 156RE in RB) |
| 4 | 15616 |
| 3 | 11784 |
| 2 | 7824 |
| 1 | 3912 |

In our opinion value 3 meets 10Mbits per second for FD-FDD UE.  |
| FL2 | Based on received responses, the following updated proposal can be considered, where the square brackets still indicate that the values are working assumptions which will be revisited.**High Priority Proposal 3-1b:****For UE peak data rate reduction, down-select between the following options:*** **Option 1: ~~If~~ UE peak data rate reduction is supported as an add-on to UE BB bandwidth reduction.**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [3].**
* **Option 2: ~~If~~ UE peak data rate reduction is supported as a standalone feature.**
	+ **The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**
 |
| OPPO | N | We would only have one value.And it seems too early to agree both options. |
| Nordic  | N | Even for 11PRB (30kHz SCS), max TB within a slot is 5128 if the constraint is relaxed to 3, this allows for peak rate of 10,256 Mbits in DL So for baseline 1Rx FD-FDD, UE peak rate of 10Mbits can be met with value 3. In our opinion down-selection is not technically correct, because if PR1 is standalone feature from BW3, UE can always implement both PR1 and BW3. We already had a consensus that PR1 is recommended to be an add-on to BW3. This is why proposal should be as the following* + **UE peak data rate reduction is supported at least as an add-on to UE BB bandwidth reduction feature. The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [3].**
		- **FFS UE peak data rate reduction is supported as a standalone feature. The constraint *vLayers*·*Qm*·*f* ≥ 4 is relaxed to *vLayers*·*Qm*·*f* ≥ [1].**
 |
| Nokia, NSB | Y | We are OK to decide between add-on versus standalone as this issue will be discussed in RAN plenary so RAN1’s input/agreement would be very helpful. Our preference is Option 1 as recommended by RAN1 in the TR. In our analysis, the constraint would need to be relaxed to around 3.4, but we can further discuss the exact value. |
| FUTUREWEI | N | The SI conclusion was clear that PR1 would be an add-on, the question is whether it would be an add-on only, or could also be used standalone. The formulation is to downselect between standalone only or add-on only. So again we recommend, if PR1 is used as an add-on the constraint is [3], FFS the standalone case.If we get stuck here, we are also OK to revisit after the decision on whether standalone is supported (here or at RAN). |
| Apple  |  | To be honest, for ‘add-on’ feature, relaxing the product value from 4 to 3.2 is fairly marginal and not bring any meaningful L2 buffer size reduction as well as cost reduction. We really doubt RAN1 should spend efforts to standardize this kind of feature. On the option of standalone feature, we understand the concern based on the 3GPP discussion history. On the other hand, kindly note that the current spec restriction is ‘$v\_{Layers}^{(j)}⋅Q\_{m}^{\left(j\right)}⋅f^{(j)}$ is no smaller than 4’. Even in Rel-15, UE is allowed to report ‘$v\_{Layers}^{(j)}⋅Q\_{m}^{\left(j\right)}⋅f^{\left(j\right)}=6$’, ‘$v\_{Layers}^{(j)}⋅Q\_{m}^{\left(j\right)}⋅f^{\left(j\right)}=4$’ etc., by selecting different combinations for these three parameters. We never call there are multiple types of UEs in Rel-15. It is our view that we should focus on introducing a useful feature to make eRedcap attractive, instead of blocking a useful mechanism with overstating the potential impact.  |

# 4 Early indication

**Early indication in Msg1/MsgA PRACH**

Several contributions [8, 10, 12, 18, 19, 21, 22, 28, 29, 33] express that a separate indication in Msg1/MsgA PRACH specifically for Rel-18 RedCap UEs can be supported, whereas other contributions [14, 15, 24, 31, 32, 35] want to study further whether the separate indication should be supported or not. Some contributions [9, 11, 16, 23] express that it is not necessary and/or should not be supported.

A few contributions [20, 27] express that separate early indication in Msg1 can be supported for UE BB bandwidth reduction, whereas the contribution [20] expresses that separate early indication specifically for the combination of UE BB bandwidth reduction and UE peak rate reduction should not be supported. The contribution [27] also expresses that early indication in Msg1 for standalone peak rate reduction needs further study, and that only one separate early indication should be specified for all Rel-18 RedCap UEs.

**Early indication in Msg3/MsgA PUSCH**

Some contributions [9, 15, 16, 22, 28] express that a separate early indication in Msg3 and/or MsgA PUSCH can be supported, whereas a few contributions [24, 35] want to study further whether the separate indication is supported or not. One contribution [11] expresses that the separate indication in Msg3 should not be supported. Another contribution [14] expresses that it should be up to RAN2 to decide whether/how to support Msg3 indication. A couple of contributions [20, 27] express that the separate indication can be supported for UE BB bandwidth reduction, but one contribution [27] wants to study further whether it should also be supported for standalone peak rate reduction.

**FL1 High Priority Proposal 4-1a: Rel-18 RedCap UEs (supporting UE complexity reduction functionality introduced by this WI) can use the same early indication in Msg1/Msg3/MsgA as Rel-17 RedCap UEs.**

* **FFS: whether to also support separate early indication in Msg1/Msg3/MsgA for Rel-18 RedCap UEs**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Huawei, HiSilicon |  | In our view, this proposal is related to FL1 Proposal 2-5a. Therefore, we suggest to make more progress on RAR handling first and the issue of intra-slot hopping of Msg3 (whether the effective bandwidth after intra-slot hopping can exceed 5 MHz) before we discuss this proposal. |
| Nordic | Y | Agree with HW |
| MediaTek |  | More discussion and consensus are needed on broadcast PDSCHs and RACH messages before we can understand whether a separate early indication is indeed needed for Rel-18 eRedCap. |
| FUTUREWEI |  | Our understanding from RAN#97 was that we would at least support the possibility of same early indication, but from the GTW today we should probably craft a full proposal considering hopping, R18 when R17 is not present, etc. rather than have FFS. |
| Nokia, NSB | Y | We support the ability to configure the same early indication to identify both Rel-17 and Rel-18 RedCap UE. We are fine to study further the ability to configure separate early indication for Rel-18 RedCap UE. |
| Qualcomm | N | We prefer to define separate early indication for Rel-18 RedCap UEs in order to allow NW to choose the configuration between separate early indication or same early indication between Rel-18 UEs and Rel-17 UEs. We also agree that we need further discussion on broadcast channels. Rather than agreeing on the current proposal with FFS, it would be good to discuss broadcast channel discussion first and come back to the early indication discussion. |
| China Telecom |  | We think it can support both the same and separate early indication in Msg1/Msg3/MsgA for Rel-18 RedCap UEs for better feasibility. |
| Sharp | Y | We support the proposal. |
| CATT | Y | The proposal is not wrong so we support.Regarding HW’s comment on frequency hopping, we have similar understanding that frequency hopping interval of PUSCH should be allowed to be >5MHz, where each hop is within 5MHz. |
| vivo |  | We support the main bullet and suggest to remove the entire subbullet, since the WID already says “Check in RAN#98-e regarding:* Whether or not/how a separate early indication can be supported”

So, we do not need to repeat this point. Besides, we share same views as other companies that whether to support separate early indication should be discussed after we have common understanding on what Rel-18 eRedCap is.  |
| ZTE, Sanechips | Y | When the separate initial BWP is configured with 5MHz bandwidth, it is possible for the Rel-18 RedCap UE and Rel-17 RedCap UE to share the same early indication in Msg1/Msg3/MsgA.When initial DL BWP is larger than 5MHz, separate early indication for Rel-18 RedCap in msg3 also should be considered to mitigate the impacts on legacy UEs scheduling. |
| DOCOMO | Y | We share the same view as HW. In addition, we would like to clarify whether “Rel-18 RedCap UEs (supporting UE complexity reduction functionality introduced by this WI)”in this proposal implies that the UE supports both or either BW reduction and peak rate reduction feature. |
| Spreadtrum | Y | We are fine with this proposal, and we see the benefit to support separate early indication for Rel-18 RedCap UEs. In addition, the issue may need RAN2’s views. |
| SONY | Y | Agree with other companies that more discussion on broadcast PDSCH / RAR is needed before deciding whether a separate early indication for eRedCap-R18 UEs is needed. |
| CMCC | Y | We think it can share same early indication as R17 since most of initial access procedure can be shared.For Msg3, since the RF bandwidth is 20MHz, we think supporting intra frequency hopping span more than 5MHz is acceptable as long as the bandwidth of each hop is smaller than 5MHz.For RAR and Msg3, the payload is limited, so early indication by Msg1 is not necessary, unless critical issue is find considering the fragment of PRACH resources.Early indication by Msg3 can be further discussed if larger payload of Msg4 is allowed. |
| Panasonic |  | Early indication can be discussed after more eRedCap functions are stabilized. |
| Xiaomi |  | We are fine with the main bullet and support to further study whether separate early indication is needed for eRedCap.  |
| Ericsson | Y | We think FFS sub-bullet in the proposal handles the concerns of Huawei/HiSilicon. |
| Samsung | Y | We are fine for the proposal. How to support same/separate early indication can be up to RAN2. |
| NEC | Y | Agree with Huawei. |
| LGE | Y | We think the separate early indication for Rel-18 RedCap should be supported, but the current proposal itself seems okay for now. |
| Sequans | Y | Agree to discuss after progress in proposal 2-5a |
| Intel | Y | Agree with HW to first clarify handling of RAR/msg3 and msg4.  |
| FL2 | Based on received responses, this topic can be revisited later. |

**FL1 Medium Priority Question 4-2a: Is a separate early indication in Msg1 for Rel-18 RedCap UEs needed?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

**FL1 Medium Priority Question 4-3a: Is a separate early indication in Msg3 for Rel-18 RedCap UEs needed?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

# 5 Other aspects

**Cell barring**

* Rel-18 RedCap UE shares the same cell access/barring indication and mechanism with Rel-17 RedCap UE. FFS additional cell access/barring indication. Final decision is up to RAN2 [14].
* A broadcasted SI indicating network support for Rel-18 RedCap is needed; network may support Rel-17 RedCap UEs but not Rel-18 RedCap UE [27].
* Introduce a new cell bar and an IFRI field in SIB1 for RedCap UEs [22].

**SSB and CORESET#0**

* FFS introducing new or reused SSB or CORESET#0 for Rel-18 RedCap. FFS how to reuse Rel-15 SSB for Option BW3 [12].
* Reuse Rel-15 SS/PBCH block for cell search and measurements for Rel-18 RedCap [18].
* Specify support of NCD-SSB for RedCap UEs in idle/inactive mode [10].

**Feature group / UE type / capability reporting**

* The basic feature group for Rel-18 RedCap includes BW3 [8].
* RAN1 defines one new Rel-18 RedCap UE type for further UE complexity reduction [15].
* Introduce new UE capability parameter for Rel-18 RedCap UEs that indicates basic functional components [15].
* BB bandwidth for PDSCH and PUSCH is an identification for the new RedCap UE type [22].
* Peak data rate reduction can be reported by the existing capability parameters *vLayers*, *Qm*and *f* [20].
* A single Rel-18 RedCap UE type should be supported for Rel-18 RedCap [12].

**Miscellaneous**

* Discuss whether to specify coverage recovery techniques for RedCap considering normal deployment scenario (i.e., not based on the Urban scenario at 4 GHz with 11 PRBs and DL PSD of 24dBm/MHz) and not considered the 3 dB antenna efficiency loss [24].
* Support/discuss enhancements for common PUCCH especially when the FH for the common PUCCH resources is disabled [24].
* For PUSCH, both CP-OFDM and DFT-s-OFDM should mandatorily be supported by RedCap UEs [30].
* For TDD, only the RF bandwidth for UL and DL needs to be aligned [15].
* Reduce BD/CCE limits for R18 Redcap UEs to half, i.e., 28CCE + 22BD per 15kHz slot, 18BDs per 30kHz SCS; Rel-18 RedCap UE monitors only one common SS per slot [34].
* DCI format sizes are the same as for legacy UEs [34].
* 16QAM is mandatorily supported while 64QAM can be optionally supported by Rel-18 RedCap [25].

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-222675](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_97e/Docs/RP-222675.zip) | New WID on enhanced support of reduced capability NR devices | Ericsson |
| [2] | [R1-2208361](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208361.zip) | WI work plan for Rel-18 RedCap | Rapporteur (Ericsson) |
| [3] | [R1-221163](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_96/Docs/RP-221163.zip) | Summary of [Rel-17] WI on support of reduced capability (RedCap) NR devices | Ericsson |
| [4] | [R1-2205427](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2205427.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [5] | [TR 38.865 V18.0.0](https://ftp.3gpp.org/Specs/archive/38_series/38.865/38865-i00.zip) | Study on further NR RedCap UE complexity reduction (Release 18) | RAN1 |
| [6] | [RP-222633](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_97e/Docs/RP-222633.zip) | Moderator’s summary for discussion [97e-15-R18-RedCap] | Moderator (Ericsson) |
| [7] | [R1-2208362](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208362.zip) | Further RedCap UE complexity reduction | Ericsson |
| [8] | [R1-2208387](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208387.zip) | Discussion on details for R18 RedCap complexity techniques | FUTUREWEI |
| [9] | [R1-2208416](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208416.zip) | Discussion on potential solutions to further reduce UE complexity | Huawei, HiSilicon |
| [10] | [R1-2208560](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208560.zip) | Discussion on enhanced support of RedCap devices | Spreadtrum Communications |
| [11] | [R1-2208653](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208653.zip) | Discussion on UE further complexity reduction | Vivo, Guangdong Genius |
| [12] | [R1-2208775](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208775.zip) | Discussion on UE complexity reduction | China Telecom |
| [13] | [R1-2208842](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208842.zip) | Technologies for further reduced UE complexity | OPPO |
| [14] | [R1-2208986](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208986.zip) | Discussion on further complexity reduction for eRedCap UE | CATT |
| [15] | [R1-2209004](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209004.zip) | RedCap UE Complexity Reduction | Nokia, Nokia Shanghai Bell |
| [16] | [R1-2209062](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209062.zip) | Discussion on complexity reduction for eRedCap UE | Intel Corporation |
| [17] | [R1-2209109](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209109.zip) | UE complexity reduction for eRedCap | Sony |
| [18] | [R1-2209163](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209163.zip) | Discussion on Rel-18 RedCap UE | NEC |
| [19] | [R1-2209170](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209170.zip) | Discussion on UE complexity reduction | Transsion Holdings |
| [20] | [R1-2209194](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209194.zip) | Discussion on further UE complexity reduction | ZTE, Sanechips |
| [21] | [R1-2209221](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209221.zip) | UE complexity reduction | Lenovo |
| [22] | [R1-2209295](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209295.zip) | Discussion on further complexity reduction for eRedCap UEs | Xiaomi |
| [23] | [R1-2209347](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209347.zip) | Discussion on further UE complexity reduction | CMCC |
| [24] | [R1-2209451](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209451.zip) | Discussion on further UE complexity reduction for eRedCap | LG Electronics |
| [25] | [R1-2209519](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209519.zip) | On further UE complexity reduction for RedCap | MediaTek Inc. |
| [26] | [R1-2209591](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209591.zip) | Discussion on further RedCap UE complexity reduction | Apple |
| [27] | [R1-2209663](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209663.zip) | Considerations for further UE complexity reduction | Sierra Wireless. S.A. |
| [28] | [R1-2209684](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209684.zip) | Discussion on UE complexity reduction | Sharp |
| [29] | [R1-2209741](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209741.zip) | Further UE complexity reduction for eRedCap | Samsung |
| [30] | [R1-2209791](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209791.zip) | UE complexity reduction for eRedCap | Panasonic |
| [31] | [R1-2209866](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209866.zip) | Discussion on UE complexity reduction | DENSO CORPORATION |
| [32] | [R1-2209912](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209912.zip) | Discussion on further UE complexity reduction for eRedCap | NTT DOCOMO, INC. |
| [33] | [R1-2209995](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209995.zip) | UE complexity reduction for eRedCap | Qualcomm Incorporated |
| [34] | [R1-2210196](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210196.zip) | On further complexity reduction of NR UE | Nordic Semiconductor ASA |
| [35] | [R1-2210283](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210283.zip) | Further RedCap UE complexity reduction(revision of [R1-2208362](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208362.zip)) | Ericsson |
| [36] | [R1-221024](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210248.zip) | FL summary #1 on Rel-18 RedCap UE complexity reduction | Moderator (Ericsson) |