**3GPP TSG RAN WG1#100bis-e R1-**

**e-Meeting, April 20th – 30th, 2020**

**Agenda Item: 7.2.2.1.2**

**Source: Moderator (Lenovo)**

**Title: Email discussion/approval on special states/indications in “available RB set indication” and COT duration indication/determination (NR-U DL Signals and Channels)**

**Document for: Discussion, Decision**

# Scope and issues based on company submissions

According to the guidance by RAN1 (vice-)chairman, this email discussion is to be finalised by 24 April; if necessary, followed by endorsing the corresponding TPs by 30 April.

## Special states/indications in "available RB set indication"

### Huawei (R1-2001532)

In TS38.213 v16.1.0, the following text was captured.

If a UE is provided *availableRB-SetPerCell-r16,* the UE is not required to monitor PDCCH candidates that overlap with any RB from RB sets that are indicated as unavailable for receptions by DCI format 2\_0 as described in Clause 11.1.1.

When UE is not configured to detect available RB set indicator or UE fails to detect DCI format 2\_0 carrying available RB set indicator, UE should monitor PDCCH on each RB set.

If the transmission occasion of DCI format 2\_0 carrying available RB set indicators locates at beginning of a DL COT, gNB is not able to update the fields according immediately after LBT. It is beneficial to define a mechanism to indicate UE the values of available RB set indicator fields in the detected DCI format 2\_0 is not valid and will be updated later. UE will still monitor PDCCH in each RB set until receiving an available RB set indicator with valid indication. A contradiction indication mechanism can be used in such case. For example, gNB is indicating all RB sets are not available in a DCI format 2\_0 (all “1” in available RB set indicator field) while UE detects the DCI format 2\_0 in at least one of the RB set. In order to avoid ambiguity, gNB should avoid configure UE to detect DCI format 2\_0 on a RB set which does not overlap with any RB sets indicated by available RB set indictors. It is also not good to indicate all RB set are available (all “0”) in such case, although the behavior of PDCCH monitor is same. It will impact LBT type switch to be discussed in the follow paragraphs.

***Proposal 8: When UE detect a DCI format 2\_0 carrying available RB set indicator indicating all RB sets are unavailable including the RB set where the detected DCI format 2\_0 locates, UE will assume the current available RB set indication is not valid and continue monitoring PDCCH candidates on these RB sets if configured. The corresponding text proposal is in TP#3 in the appendix.***

###  ZTE (R1-2001703)

For the case that the gNB has just occupied an unlicensed carrier and a downlink transmission has just started, there is no enough time for the gNB to prepare current available RB-set information in the DCI format 2\_0. In this case, the gNB can send the bitmap with all "1" to the UE at the beginning of the COT, and re-transmit DCI format 2\_0 with accurate available RB-set information at the next moment. But we believe that this is an implementation behavior and transparent to UE, thus has no specification impact.

**Proposal 3: For the case that a gNB has just occupied an unlicensed carrier and a downlink transmission has just started, there is no enough time for the gNB to prepare current available RB-set information in the DCI format 2\_0:**

* **The gNB can send the bitmap with all "1" to the UE at the beginning of the COT, and re-transmit DCI format 2\_0 with accurate available RB-set information at the next moment.**
* **It is an implementation behavior and transparent to UE, thus it has no specification impact.**

### OPPO (R1-2001757)

In the previous RAN1 meetings, the following agreements regarding DCI format 2\_0 were achieved:

|  |
| --- |
| Agreement:Support bit field corresponding to available LBT bandwidths in GC-PDCCH (add a bitmap in the GC-PDCCH DCI)Agreement:When the COT duration field is not configured to the UE in DCI format 2\_0, the UE may assume that the duration of the COT is the same as the duration for which SFI is provided in DCI format 2\_0.Agreement:If a UE is configured with a CSI-RS spanning over multiple LBT bandwidths,* The UE assumes that the CSI-RS is not transmitted if the UE is monitoring DCI format 2\_0 carrying an LBT BW indication and detects the DCI format 2\_0 indicating any of corresponding LBT bandwidths is not available for DL reception.
 |

DCI format 2\_0 can be used to indicate the SFI structure and the available RB sets for more than one cells. For each cell, the locations of these bit-fields in the DCI are RRC configured. Once configured, these bit-fields will be transmitted in the DCI, so UE should be indicated in the DCI for the following two cases:

* Case 1: the incorrect available RB sets information in DCI format 2\_0 if it is transmitted at the beginning of one COT while gNB does not have enough time to prepare this information.
* Case 2: the incorrect information of SFI structure and available RB sets in DCI format 2\_0 for the cell which does not pass LBT.

There was discussion that one special state of the available RB sets bit-field may be used to indicate the above case 1. This is applicable, and considering that the UE may assume the CSI-RS is transmitted if it receives the DCI format 2\_0 carrying an indication of “all the RB sets are available”, the special state of “all the RB sets are available” cannot be used to avoid confusion. Hence, the special state of “all the RB sets are not available” can be used, and if UE receives such indication, it is expected to monitor PDCCH occasions in all the RB sets.

On the other hand, to indicate the above case 2, one special state of the SFI structure bit-field may be introduced to indicate the cell which does not pass LBT. If UE receives this indication, it may ignore the information indicated in this DCI format 2\_0 for the cell.

***Proposal 14:*** *For RB set indication in DCI format 2\_0, a special state of the available RB sets indicating “all the RB sets are not available” can be used to indicate the unprepared available RB sets information.*

### MediaTek (R1-2001902)

In RAN1#100e meeting, there were discussions on how to indicate available RB-set at the beginning of DL transmission burst if it has no enough time to prepare exact available-RB-set information. To address this issue, some companies propose to define a special state in available-RB-set indication and/or CO duration/SFI indication to indicate that the detected DCI format 2\_0 does not provide the actual frequency domain availability. However, we don’t see why it is necessary to define a special state for this purpose since gNB can handle this issue according to current specifications. For example, gNB could choose not to transmit DCI format 2\_0 if the available-RB-set information is unprepared. Then, UE still performs configured DL receptions, e.g., PDCCH monitoring and CSI-RS reception, in all RB sets on the DL BWP as usual.

Even a special state is defined, how UE assume the availability of the RB sets in a carrier if UE detects a DCI format 2\_0 indicating the special state? If UE assumes all RB sets are unavailable, it seems meaningless to indicate such information to UE. If UE assumes all RB sets are available, it will lead to violation of regulation since UE may switch LBT from Cat.4 to Cat.2 for UL transmissions even the UL transmissions are not fully located in a channel occupancy in frequency domain. If UE assumes all RB sets are neither available nor unavailable, i.e., unknown, it is equivalent to the DCI format 2\_0 is not transmitted/detected.

Consequently, we don't any benefit to define a special state for handling the unprepared available-RB-set information at the beginning of DL transmission burst.

**Proposal 4: It is not necessary to define a special state in available-RB-set/CO duration/SFI indication to indicate that the detected DCI format 2\_0 does not provide the actual frequency domain availability.**

### LG (R1-2001933)

DCI format 2\_0 for NR-U can be used for notifying available RB sets, in addition to channel occupancy duration, search space set group switching, and slot format (as in Rel-15). Especially for indicating available RB sets, the UE can be provided with a location of a bitmap in DCI format 2\_0, having a one-to-one mapping with a set of RB sets of the serving cell, where a value of '0' indicates that an RB set is available for receptions and a value of '1' indicates that an RB set is not available for receptions, by *availableRB-SetPerCell-r16*, and the bitmap in DCI format 2\_0. The RB set remains available or unavailable until the end of the indicated channel occupancy duration, as described in TS 38.213 section 11.1.1.

First of all, it should be clarified how to inform in which RB set(s) serving gNB is transmitting at the beginning in its DL burst. The serving gNB may not have sufficient processing time to signal its actually transmitting RB set(s) since gNB cannot predict LBT outcome before starting to transmit DL burst. For this case, the serving gNB can indicate that this slot is at the beginning of its DL burst by using all one state for the bitmap.

Secondly, the interpretation of all one state for the bitmap may depend on whether the code point of bitmap indicating available RB sets for its own carrier corresponds to all ‘1’ or not. Figure 2 depicts one example of DCI format 2\_0 with available RB sets for both of carriers #1 and #2, where gNB grabs the channel only for carrier #1 with 2 RB sets but not for carrier #2. In Slot#n, gNB transmits DCI format 2\_0 with all one state for carriers #1 and #2. If a UE detects DCI format 2\_0 transmitted in carrier #1, the UE recognizes that all one state for the same carrier #1 and also for the other carrier #2 represents the beginning of DL burst. On the other hand, in Slot#n+2, since the code point of bitmap for carrier #1 corresponds to ‘00’ (not all one state), the UE can consider that all one state for the other carrier #2 represents the gNB cannot access the channel due to LBT failure.



**Figure 1. Example of DCI format 2\_0 notifying available RB sets for multiple carriers**

**Proposal #4: If a UE is monitoring a DCI format 2\_0 indicating available RB sets for the first carrier and also for the second carrier and the UE detects the DCI format 2\_0 on the first carrier,**

* **If the bitmap corresponding to the first carrier is signalled to all ‘1’,**
	+ **The UE recognizes that DL burst has just started to be transmitted for the first carrier and also for the second carrier where the corresponding bitmap is signalled to all ‘1’, and the UE expects that available RB sets for the first and second carriers may be updated during this DL burst.**
* **Otherwise,**
	+ **For the second carrier where the corresponding bitmap is signalled to all ‘1’, the UE does not expect any DL receptions on the second carrier during channel occupancy time.**

###  Intel (R1-2001985)

As shown in the highlighted part of the above agreement, it was discussed what to indicate in the RB set indicator field if the gNB could not prepare the correct RB set indicator field for DCI 2\_0 due to insufficient time between LBT operation and the actual transmission of DCI 2\_0, e.g., at the beginning of DL transmission burst. One possible way is to reserve all-zero bitmap for this indication since DCI 2\_0 cannot be transmitted if none of RB-sets are available. However, it is applicable only for self-carrier indication and all-zero bitmap needs to be transmitted for cross-carrier indication when none of RB-sets are available due to LBT failure when carrier aggregation is configured.

Therefore, we can differentiate the indication method between self-carrier indication and cross-carrier indication scenarios. For self-carrier indication, we can reserve all-zero bitmap as the indication that RB set indicator field is not available and it can be updated in the following DCI 2\_0 if available inside the acquired COT. On the other hand, for cross-carrier indication, we can utilize all-one bitmap as the indication that RB set indicator field is not available and it can be updated in the following DCI 2\_0 if available.

If this behaviour if formulated from a UE perspective,

* If RB set indicator field is all-one,
	+ if the indication is for the same carrier, then the UE assumes all RB sets in BWP are available for reception, but it can be updated in next DCI format 2\_0 if available inside the same COT
	+ if the indication is for the different carrier, then the UE assumes none of RB sets in BWP are available for reception for the duration indicated by DCI 2\_0
* If RB set indicator field is all-zero,
	+ if the indication is for the same carrier, then the UE assumes all RB sets in BWP are available for reception for the duration indicated by DCI 2\_0
	+ if the indication is for the different carrier, then the UE assumes all RB sets in BWP are available for reception, but it can be updated in next DCI format 2\_0 if available inside the same COT

**Proposal 1:**

* **If RB set indicator field is all-one,**
	+ **if the indication is for the same carrier, then the UE assumes all RB sets in BWP are available for reception, but it can be updated in next DCI format 2\_0 if available inside the same COT**
	+ **if the indication is for the different carrier, then the UE assumes none of RB sets in BWP are available for reception for the duration indicated by DCI 2\_0**
* **If RB set indicator field is all-zero,**
	+ **if the indication is for the same carrier, then the UE assumes all RB sets in BWP are available for reception for the duration indicated by DCI 2\_0**
	+ **if the indication is for the different carrier, then the UE assumes all RB sets in BWP are available for reception, but it can be updated in next DCI format 2\_0 if available inside the same COT**

### Sharp (R1-2002381)

In RAN1#100\_e, it was actively discussed whether/how to introduce a special value of RB set indicator [4]. The main motivation is to inform UEs of that the gNB is not aware of availability of other RB sets than the one where the DCI format 2\_0 is detected, which happens when the gNB generates DCI format 2\_0 before getting channel access. There are several proposals [5][6][7]. They have similar principle for self-indicating case, i.e. DCI format 2\_0 on a serving cell indicates the availability of RB sets within the same serving cell, as follows. From our perspective, this is reasonable.

* The value of all ‘1’ indicates that the gNB is not aware of availability of other RB sets than the one where the DCI format 2\_0 is detected.

Meanwhile, companies had different views on cross-indicating cases.

* Option 1: Same as self-indicating case, i.e. the value of all ‘1’ indicates that the gNB is not aware of availability of other RB sets than the one where the DCI format 2\_0 is detected.
* Option 2: Unlike self-indicating case, i.e. the value of all ‘1’ indicates that all RB sets are not available.
* Option 3: If CO duration is not set to zero, the value of all ‘1’ indicates that all RB sets are not available. If CO duration is set to zero, it means that the gNB is not aware of availability of all RB sets in the serving cell.

For cross-carrier indicating case, there is a possibility that all RB sets are not available, which should be informed of UEs. At the same time, informing unawareness of availability is also useful even in cross-carrier indicating case. Therefore, we support Option 3 in principle.

For UE behaviours for the case the gNB is not aware of availability of a given RB set, it can be the same as for outside of CO.

**Proposal 9:**

* **UE behaviours for RB sets for which the gNB is not aware of LBT status should follow the behaviour for outside CO durations.**
	+ **Adopt the above Text proposal #5, for a cross-carrier indication case.**
* **TS38.213 to capture the special value (i.e. all ‘1’) of the RB set indicator value for a self-indication case when the gNB is not aware of LBT status of other RB sets.**
	+ **Adopt the following Text proposal #8.**

[FL Note: TP is provided in the document]

## Intra-cell guardband between two adjacent RB sets

### Apple (R1-2002322)

For wide-band operation on unlicensed band, it was agreed to introduce intra-cell guard bands between two adjacent RB sets with an RB level granularity. In addition, minimum guard band requirement defined by RAN4 is used as the guard bands when no semi-static value is configured by higher layers. In the RAN1 #92bis meeting, two types of intra-cell guard bands were defined on a common grid, which are termed as Type-1 and Type-2. Type-2 intra-cell guard band is located within the adjacent contiguous RB sets where one of them has passed LBT. Consensus was further made regarding the scheduling feasibility on intra-Cell Guard Bands as follows [1]:

|  |
| --- |
| * *The intra-carrier guard band could be scheduled if it is located within the adjacent contiguous LBT successful sub-bands where all scheduled LBT sub-bands have passed*
* *Scheduling in Type-2 intra-carrier GBs is not feasible*
 |

So far, RAN4 agreed to support at least 40/60/80MHz bandwidth for NR-U wideband operation, which consists of up to four RB sets. In RAN1#100e meeting, the issue of PDSCH transmission has been raised regarding how to signal the availability of intra-cell guard bands for Type-0 resource allocation. The situation becomes more complicated considering the fact that the type of a given intra-cell guard-band can be time-varied within a COT duration e.g. LBT fails at start and succeeds in the middle of COT.

One solution proposed in last meeting was to reuse the rate matching pattern framework that was defined in Rel-15 to dynamically indicate the availability of intra-cell guard-band for Type-0 PDSCH transmission by scheduling DCI format 1\_1. Note that, Rel-15 supports up to two groups of rate-matching resource resources, which were configured by RRC signalling and dynamically activation/deactivation using 2-bits field in DCI format 1\_1. Up to two groups works well to signal the availability of intra-cell guard bands in case of smaller BWP up to 60MHz but is not sufficient for larger BWP (e.g. 80MHz) as illustrated in FIG.1. In this example, 80MHz BWP is considered, which covers 4 RB sets indexing from 0 to 3. The total number of Type-2 intra-CC guard bands combinations can be up to 14 as shown in FIG.1. As a consequence, for dynamic activation/deactivation of rate-matching resource set group, at least three groups of rate-matching resource sets are needed to independently indicate the presence of GP1/GP2/GP3, implying the need for one additional rate-matching group indicator bit in scheduling DCI format. Although the requested rate matching groups can be further reduced to two with sacrificing spectrum efficiency (e.g. assuming one of GP0/1/2 is always not available for resource allocation and then dynamic indicates the presence of other two GPs using two bits as in legacy), it imposes too much unnecessary scheduling restriction at the gNB side for Type-0 RA for wideband operation, which eventually results in throughput loss.

Additional consideration is needed for the collision between PDSCH DMRS REs and rate-matching pattern. In [2], it was agreed that PDSCH DMRS REs indicated by the frequency domain resource assignment field in a DCI are always transmitted and not overlapping with any RM pattern. As a consequence, reusing rate-matching pattern cannot null out some PRBs at front loaded DMRS and additional DMRS and therefore cannot be flexibly used to create the intra-CC guard band to achieve interference mitigation function.



To avoid unnecessary restriction of intra-CC guard band utilization, one simpler way is to utilize the RB sets information provided in DCI format 2\_0 if it is present. As one example, if availableRB-SetPerCell-r16 is configured and detected in a DCI format 2\_0, the availability of intra-CC guard band for PDSCH transmission can be derived at the UE side correspondingly. One issue needs to be discussed is how to handle the RBG that is partially overlapped with Type-2 intra-CC guard band for the Type-0 resource allocation scheme.

Three options exist to solve this problem:

* Option 1: The RBG partially overlapped with Type-2 intra-CC guard band is not used for Type-0 RA.
* Option 2: The RB overlapped with Type-2 intra-CC guard band is not available for Type-0 RA.
* Option 3: The PRG partially overlapped with Type-2 intra-CC is not used for Type-0 RA



As shown in FIG.2, the Opt. 1 is the simplest solution from UE implementation perspective but may significantly impact the PDSCH performance as the entire RBG cannot be used, especially considering the RBG size can be up to 16 for a wide-band BWP. Although the Opt.2 provides the best resource utilization i.e. all non-overlapped RBs are addressable, it violates a very fundamental design principle that is widely used in Rel-15 NR i.e. only the first PRG and last PRG can have smaller sizes while all other PRGs in between end up with same PRG size as configured. As a result, it’ll inevitably introduce complexity at both transmitter and receiver to process increased number of smaller PRG(s) that are punctured by intra-CC guard band e.g. PRG#3 with 1 RB. Opt.3 provides a good trade-off between UE complexity (i.e. no need of handling different sizes of PRG) and throughput performance. This flexibility is beneficial and important to keep the PRG size identical across frequency domain allocation except for the first PRG and last PRG in the same way as in Rel-15 NR baseline. It should be also noted that one PRG consists of either 2 and 4 PRBs and excluding one punctured PRG overlapped with intra-CC guard band would not result in any material spectrum efficiency loss. It is especially true when PRG size is configured to be 2, which is fully controlled by gNB scheduler. Based on the discussions above, Opt.3 is clearly more feasible and better design and therefore preferable to address this problem.

One more discussion point for Type-0 resource allocation is how to handle the case when precoding granularity is configured as ‘wideband’. As in legacy, in case of wideband precoding configuration, the UE is not expected to be scheduled with non-contiguous PRBs and UE may assume that a same precoding is applied to the allocated resource. Unlike the case of PRG=2/4RB precoding, support of RB-level rate-matching is feasible to improve the resource efficiency.

**Proposal 1:**

* *If available RB Sets indictor is provided in a detected DCI format 2\_0 and DL Type 0 resource allocation is used for PDSCH resource allocation,*
* *If precoding granularity is equal to the values among {2,4}, the UE shall assume the PDSCH and DMRS are not mapped to any PRG that is partially overlapped with a Type 2 intra-CC guard band.*
* *If precoding granularity is determined as “wideband”, the UE shall assume the PDSCH and DMRS are not mapped to any RB(s) that is partially overlapped with a Type 2 intra-CC guard band.*

## COT duration indication/determination

### vivo (R1-2001650)

In RAN1#100e [2], the following agreement was made on COT duration indication:

Agreement:

The value for a single channel occupancy duration value (co-Duration-r16) can range from 0 to 20 ms with a granularity of one symbol.

Clearly, COT duration is in symbol level granularity so that the start of this COT indication should be also a certain symbol. However, current spec in section 11.1.1 of TS 38.213 says “*CO-DurationPerCell-r16 indicates a remaining channel occupancy duration for the serving cell starting from a slot where the UE detects the DCI format 2\_0 by providing a value from CO-DurationList-r16*”, which doesn’t specify the concrete starting symbol. Then we propose to use the first symbol of PDCCH where the UE detects the DCI format 2\_0 as the start of indicated COT duration. Using the first symbol here instead of the last symbol is to avoid the misunderstanding between gNB and UE when early decoding of PDCCH happens. For example, gNB transmits one PDCCH carrying COT information with AL16 in 2-symbol coreset but UE decode the PDCCH with AL8 in the first symbol. In this case if using last symbol of the PDCCH, gNB uses the 2nd symbol while UE assumes the 1st symbol of PDCCH as starting symbol of COT indication. Thus, using the first symbol of PDCCH could avoid such misunderstanding between gNB and UE.

**Proposal 3: RAN1 adopt the following TP2 on section 11.1 of TS 38.213.**

------------------------------------------- Start TP2 for Section 11.1 of TS 38.213 --------------------------------------

* a location of a channel occupancy duration field in DCI format 2\_0, by CO-DurationPerCell-r16, that indicates a remaining channel occupancy duration for the serving cell starting from ~~a slot~~ the first symbol of PDCCH where the UE detects the DCI format 2\_0 by providing a value from CO-DurationList-r16. The channel occupancy duration field includes $max\left\{\left⌈log\_{2}\left(COdurationListSize\right)\right⌉,1\right\}$ bits, where $COdurationListSize$ is the number of values provided by CO-DurationList-r16. If CO-DurationPerCell-r16 is not provided, the remaining channel occupancy duration for the serving cell is a number of slots, starting from a slot where the UE detects the DCI format 2\_0, that the SFI-index field value provides corresponding slot formats.

--------------------------------------------- End TP2 for Section 11.1 of TS 38.213 --------------------------------------

### LG (R1-2001933)

In RAN1#100-e meeting, it was agreed that the value for a channel occupancy duration value (*co-Duration-r16*) can range from 0 to 20 ms with a granularity of one symbol. One remaining issue for indicating the channel occupancy duration value is to determine its starting position. Simply, it can start from the ending boundary of a slot where the corresponding DCI format 2\_0 is detected.

**Proposal #1: Adopt the following text proposal in TS 38.213 section 11.1.1.**

|  |
| --- |
| 11.1.1 UE procedure for determining slot format**<Unchanged parts are omitted>**- a location of a channel occupancy duration field in DCI format 2\_0, by *CO-DurationPerCell-r16*, that indicates a remaining channel occupancy duration for the serving cell starting from the end of a slot where the UE detects the DCI format 2\_0 by providing a value from *CO-DurationList-r16*. The channel occupancy duration field includes $max\left\{\left⌈log\_{2}\left(COdurationListSize\right)\right⌉,1\right\}$ bits, where $COdurationListSize$ is the number of values provided by *CO-DurationList-r16*. If *CO-DurationPerCell-r16* is not provided, the remaining channel occupancy duration for the serving cell is a number of slots, starting from a slot where the UE detects the DCI format 2\_0, that the SFI-index field value provides corresponding slot formats |

In addition on SFI-index field, channel occupancy duration field can be configured in DCI format 2\_0 for the same serving cell. In this case, it may happen that remaining channel occupancy time is shorter than the number of slots for which SFI-index field provides corresponding slot formats, since the minimum number of slots for each SFI-index field is pre-defined based on the periodicity configured for associated search space set. Considering slot format information outside of channel occupancy acquired by gNB may not be guaranteed, it would be beneficial for a UE to ignore slot format information outside of remaining channel occupancy.

**Proposal #3: If a UE detects DCI format 2\_0 indicating remaining channel occupancy time shorter than the number of slots for which SFI-index field provides corresponding slot formats, the UE ignores slot format information corresponding to slots outside of gNB’s channel occupancy time.**

### Sharp (R1-2002381)

So far, it has not been clarified how CO duration affects UE behaviours. In our view, the UE behaviours for outside of CO duration should follow the ones for the cases when the UE has not detected the DCI format 2\_0 providing the slot format for the concerned resources (e.g. performing PDCCH monitoring, not performing higher-layer configured DL receptions).

In addition, the current Spec does not capture the case where CO duration indication is configured but SFI is not configured. For the symbols that CO duration indication indicates as inside of CO and if the UE is not configured to monitor SFI, the UE should assume the procedure defined in 11.1 (i.e. follow semi-static UL/DL configuration) for those symbols.

**Proposal 5:**

* **UE behaviours for outside CO duration should be the same as for the case when the UE has not detected a DCI format 2\_0 providing a slot format.**
	+ **Adopt the 1st and 2nd paragraphs in the following Text proposal #5.**

[FL Note: TP is provided in the document]

# Discussion

Companies are invited to comment on the questions below.

## Special states/indications in "available RB set indication"

For all questions in this section, please take into account all the points from company contributions listed in section 1.1.

ZTE as well as MediaTek indicate that no special state is necessary for the case that the DCI format 2\_0 is transmitted before the available RB-set information can be reflected therein. According to ZTE, all "1" could be transmitted intially, which can be updated whenever the information becomes available.

Please note that the terminology "special state" needs to be seen from the UE perspective of the RB set indication. So far, we have a bitmap where a value of '0' indicates that an RB set is available for receptions and a value of '1' indicates that an RB set is not available for receptions. In other words, all "0" currently implies that all RB sets are available for reception, while all "1" currently implies that no RB sets are available for reception. Defining a special state therefore needs to define an exception from that interpretation.

**Q1: Do you think that an exceptional UE behaviour that is different from the current behaviour for one or more RB set information is required?**

|  |
| --- |
| If your answer is "Yes", please provide cases where such an exceptional UE behaviour is required or beneficial.If your answer is "No", it would be appreciated if you provided why you do not see a benefit. |
| **Company** | **Comment** |
| Huawei, HiSilicon | Yes, the special value is necessary. It will be used at beginning of DL burst immediately following LBT.  |
| MediaTek | No. The required UE behaviors at beginning of DL burst immediately following LBT can be achieved by current spec. For example:* UE is required to monitor PDCCH candidate on all RB sets -> Not transmit the DCI 2\_0
* UE is required to switch CAT4 LBT to CAT2 LBT for an UL transmission at beginning of DL burst on the RB set in which DCI format 2\_0 is detected -> gNB could prepare a DCI 2\_0 indicating only the RB set in which DCI 2\_0 to be transmitted is available for DL reception before the LBT outcome is determined.
 |
| Nokia, NSB | No, but default behavior for the case when RB-set indication is not configured is now missing. |
| LG Electronics | YES. For NR-U, DCI format 2\_0 provides various functionalities in addition to available RB set indication. It is the common sense that gNB may not be possible to carry correct information for RB set availability at the beginning of DL burst. Transmission of DCI format 2\_0 at the beginning of DL burst could be beneficial for UL cancellation by using SFI index field or for SS set switching by using switching flag and CO duration field. |
| ZTE, Sanechips | No. My understanding is that if gNB doesn’t have time to prepare the available RB set information, it can not transmit it, UE can detect DL information in all RB sets as before. Or all "1" could be transmitted intially, which can be updated whenever the information becomes available. |
| Intel | Yes, the special state is needed for the beginning of DL burst and corresponding UE behavior has to be defined.  |
| Qualcomm | Yes the special value is necessary. Note that though the available RB set information is not available at the beginning of the COT, the COT duration information is likely available. So there is a need for DCI 2\_0 to be transmitted, even without available RB set information. |
| OPPO | We think a special state is needed. For case pointed out by ZTE, if all ‘1’ indicates a ‘not ready’, we need to define a state that all the RB sets are unavailable. Moreover, the ‘not ready’ case is not a rare case. Our proposal is to define a special case from SFI to represent all RB sets of the serving cell are unavailable.  |
| Sharp | Yes. Share the views form Huawei. It will be used for DCI 2\_0 transmission right after successful LBT for a self-indication case (i.e. the DCI 2\_0 on a serving cell carries available RB set information in the same serving cell.) |
| vivo | No. The special state indication is due to no enough time to prepare the DCI in GC-PDCCH right after knowing the channel availability information. There could be multiple ways for gNB implementation to deal with such case, e.g. not send the DCI at this moment or prepare multiple copies of DCI. |
| Ericsson  | No. We think that the situation can be handled using current specification by configuring proper values for RB-set availability and COT duration fields by gNB.  |
| NTT DOCOMO | No. If gNB wants to indicate SS set switching flag by the DCI 2\_0 right after successful LBT, it is enough to set the available RB set information to an arbitrary bitmap with 0 ms COT duration. |
| ZTE, Sanechips | Further clarification our opinion:All “1” mentioned in our comment mean all RB sets are available, due to we tend to support changing the interpretation of 0/1 for the RB set indicator. E.g., use “1” to indicate the resource is “available” and “0” to indicate resource is not available.If the interpretation of 0/1 for the RB set indicator is not changed in the spec, then we support all “0” state is transmitted in the starting of DL burst and this state has been supported in the current spec. So I don’t see any need to define a specific state.  |
| Spreadtrum | No. For PDCCH monitoring, even with a special states/indication, the UE still needs to monitor the PDCCH in RB sets indicated by “*FreqMonitoringLocation-r16*”, which is the same behavior when no RB set indication carried in DCI 2\_0 is received. For CSI-RS transmission validation and LBT type switching, gNB could indicate a COT duration of 0ms, and update whenever information is available.  |
| ITRI | No.If gNB doesn’t have time to prepare the available RB set information, it can not transmit it. UE is required to monitor PDCCH candidates on all RB sets. |

**Q2: If your answer to Q1 is "Yes", please indicate for such a special state, and how to indicate it. No need to fill in if your answer to Q1 in "No".**

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| **Company** | **Comment** |
| Huawei, HiSilicon | UE will be indicated all RB sets are not available for reception while UE detects DCI format 2\_0 on one of the RB set. The indication can be from multiple available RB set indicators in DCI format 2\_0 configured for UE to detect.UE behavior includes:* UE will continue monitor PDCCH candidate on all RB sets according to configured SS set and not skip PDCCH candidates on RB set according to the available RB set indicators
* UE can switch CAT4 LBT to CAT2 LBT before PUSCH within COT duration only on the RB set in which DCI format 2\_0 is detected.
* UE can switch SS set from group #0 to group#1.
 |
| Nokia, NSB | We propose TP for sub-clause 7 in 38.214 which would capture.When UE is configured with carrier comprising GBs and UE is not configured with RB-set indication in DCI 2\_0, the UE assumes all RB-sets are available.  |
| LG Electronics | The special state could be all ‘1’ indication and additional consideration point would be to differentiate self-carrier indication and cross-carrier indication. To be specific, for cross-carrier indication, all ‘1’ indication implies beginning of DL burst if all ‘1’ is also indicated for the serving cell where DCI format 2\_0 is detected; otherwise, all ‘1’ indication implies that no RB sets are available for the cross carrier. |
| Intel | (Some typos are corrected in our proposal above)For self-carrier indication, all ‘1’ bitmap is used for the special state (RB set indication is not available yet), and the UE has to assume that all RBs sets may still be available for reception and it may be updated in the next DCI 2\_0 occasion inside the same CO if available.For cross-carrier indication, all ‘1’ bitmap cannot be used for the special sate because all ‘1’ is used for indicating that none of RB sets are available for reception. However, if RB set indication is not available (special state) for cross-carrier indication, all ‘0’ bitmap can be used but this means that UE assumes all RBs sets are available for reception and it may be updated in the next DCI 2\_0 occasion inside the same CO if available. |
| Qualcomm | Before valid available RB set is not received, the UE will not use it to validate CSI-RS transmission, and UE will follow DCI for operation. HW’s proposal on using DCI 2\_0 reception RB set to validate some of the RB set for Type1 to Type 2A switching is also reasonable. UE can use other decoded DCI to validate as well. These can be left for UE implementation though. |
| Sharp | If a UE detects DCI 2\_0 on a given RB set, and if the RB set indicator in the DCI 2\_0 indicates all RB sets including the given RB set are not available:* For the given RB set, the UE considers it is indicated as being available
* For all the other RBs, the UE considers DCI 2\_0 indicating SFI/CO duration for those RB sets is not detected.
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## Intra-cell guardband between two adjacent RB sets

FL Note: For illustration purposes of RAN4 terminology of Type-1/Type-2 intra-carrier guardbands, the following figure is taken from R4-1912869:



**Q3: Do you agree to use RB sets information provided in DCI format 2\_0 for determining PDSCH and DMRS mapping to PRGs as described in Apple's proposal 1?**

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| Apple's proposal 1:* If available RB Sets indicator is provided in a detected DCI format 2\_0 and DL Type 0 resource allocation is used for PDSCH resource allocation,
	+ If precoding granularity is equal to the values among {2,4}, the UE shall assume the PDSCH and DMRS are not mapped to any PRG that is partially overlapped with a Type 2 intra-CC guard band.
	+ If precoding granularity is determined as “wideband”, the UE shall assume the PDSCH and DMRS are not mapped to any RB(s) that is partially overlapped with a Type 2 intra-CC guard band.
 |
| **Company** | **Comment** |
| **Apple** | **Of course, we support to utilize the DCI format 2\_0 to allow Type-0 RA on the RBG partially punctured by the Type-2 intra-CC guard band. Note that, DCI format 2\_0 is desirable for UE to determine the Type of intra-CC guard band, i.e. Type 1 vs. Type 2 and then perform the PDSCH rate-matching operation based on this information. In more details, in case of Type-1 intra-CC guard band, the resource is addressable and hence UE shall assume all the RBs of intra-CC guard band is available; Otherwise, if intra-CC guard band is Type-2 based on the detected DCI format 2\_0, PRG-level rate-matching should be operated to exclude the partially punctured PRG for PDSCH reception.** **It should be noted that, without this proposal and following current spec, in case of Type-2 intra-CC guard band, gNB scheduler either does NOT schedule Type-0 RA for overlapped RBG. If it schedules the intra-CC guard band with Type-0 RA, following legacy behavior, UE always try to decode PDSCH with assuming normal PDSCH transmission on Type-2 Intra-CC guard band (e.g. DMRS, etc) and consequently, the decoding maybe failed and results in spectrum inefficiency.**  |
| Huawei, HiSilicon | We agree with the proposals. Moreover, we also submitted following proposal related to this topic in R1-2001532.*Proposal 13: UE is able to determine whether there is PDSCH mapping on the intra-cell guard band(s) based on Rate Matching Indicator in DCI format 1-1 and/or available RB set indicator in GC-PDCCH. UE assumes all intra-cell guard bands are reserved if DCI format 1\_0 is used. The corresponding text proposal is in TP#4 in the appendix.* |
| MediaTek | Not agree with the proposal. Note that in RAN1#97, we have a conclusion that UE can receive a PDSCH in unlicensed band without any new agreement after RAN1#97.***Conclusion: (RAN1 #97)******A UE can receive a PDSCH scheduled within an LBT bandwidth or over multiple LBT bandwidths as per Rel-15 and current agreements in Rel-16.*** |
| Nokia, NSB | We are supportive to introduce such functionality which is precluded by specification at the moment. On the other hand, RAN1 spec does not differentiate TYPE-2 and TYPE-1 GB. The other option is to configure Rate-matching resource, which overlaps with intra-cell GBs and gNB indicating dynamically/semi-statically whether to rate-match or not. **Therefore, we propose:** A UE is not expected to handle the case where PDSCH DM-RS REs are overlapping, even partially, with any RE(s) not available for PDSCH, except when PDSCH DM-RS REs collide with resource of *RateMatchPattern* configured to be fully overlapping with an intra-cell GBs defined in sub-clause 7 and  value for the PDSCH is among {2, 4}. |
| LG Electronics | First of all, we don’t support UE behavior that relies on decoding of DCI format 2\_0 for PDSCH reception. As Apple stated, if UE follows current spec w/o introducing new behavior considering guard band, UE might perform channel estimation and data decoding based on DL DCI and fail to successfully decode PDSCH when scheduled resource is overlapped with guard band. However, in Apple’s proposal, if DCI format 2\_0 is transmitted but UE misses it, the impact on PDSCH reception would be more significant than UE behavior following current spec since understanding on rate-matching is different between gNB and UE in this case.If gNB needs to avoid spectrum inefficiency due to the fact that RBG including guard band cannot be scheduled, gNB can schedule other UE by using (RIV based) RA type 1. |
| ZTE, Sanechips | I agree with the proposal from Apple |
| Ericsson | Do not support the proposal in its current form. We are sympathetic to the UE implementation issues regarding partial PRG overlap of a guard bands; however, we are not supportive of requiring that DCI 2\_0 be configured for the UE to determine this. Also, as LGE points out, as per Rel-15, decoding of PDSCH does not rely on detection of DCI 2\_0, and it would be preferable to not deviate from this philosophy.What happens if DCI 2\_0 is not configured? Does this mean that DL resource allocation Type-0 cannot be used? Is it not possible for the UE to figure out if a Type-2 guard band is present without DCI 2\_0? Already with existing Type0 RA, the gNB can schedule the Type-1 guard bands. And if there is a Type-2 guardband, isn’t it obvious from the Type0-RA bitmap that a Type-2 guardband is present?We are okay to discuss what the UE behavior should be if a PRG partially overlaps a guard band with Type0 RA; however, we are not okay with requiring that DCI 2\_0 be decoded for the UE to figure this out; nor do we see a need for modifying rate matching behavior. Also, as LGE points out, to avoid any Type-0 RA issues, an alternative scheduling strategy can be used such that one UE can be scheduled over one set of contiguous available RB sets using Type-1 RA (RIV based), and another UE can be scheduled over another set of contiguous RB sets using Type-1 RA, then there is no special handling that is needed.  |
| Samsung | Similar view with MediaTek and LGE. As pointed by MediaTek, RAN1 concluded that a UE can receive a PDSCH scheduled within an LBT bandwidth or over multiple LBT bandwidths as per Rel-15 and current agreements in Rel-16. In our understanding, with this conclusion UE just follows FDRA in the scheduled DCI regardless of LBT outcome and overlapped with guardband. |
| Intel | We agree with the proposal in principle. One thing I’d like to point out is that it is not desirable to differentiate the behavior depending on intra-carrier guardband types. Since a UE need some filter adaptation time (as discussed in RAN4 LS in R1-1905930), it may not be possible for the UE to differentiate different types of intra-carrier guardbands at least for some time after the detection of available RB Sets indicator. For simplicity, it is more desirable that a UE assumes PDSCH is not mapped to ALL intra-cell guardbands. We agree that the rate matching granularity is PRG level or RB level depending on the precoding granularity. |
| Qualcomm | Do not agree with the proposal. We already have the agreement the UE will receive PDSCH as scheduled, so gNB should handle the FDRA properly. |
| OPPO | We think the gNB can avoid allocation PDSCH in type2-GB. Note that the type 1 resource allocation is a mandatory feature, every UE supports it. The gNB can configure both type 0 and type 1 RA for the UE and dynamically select the RA type. For the UE for whom the gNB decides to allocate close to the type 2 GB, the gNB can switch to type 1-RA, which has 1 PRB granularity. Moreover, it needs to check what the reason was for Rel-15 that the DMRS was not assumed to be rate-matched by the RM pattern. We are not sure if in Apple’s proposal the DMRS is rate matched by the type 2-GB will touch the Rel-15 issue.  |
| Sharp | We don’t support to introduce mechanism for PDSCH mapping determination based on a group common PDCCH. LG clarified the reason.Availability of intra-cell guard band between available adjacent RB sets should depend on UE’s ability. Therefore, using group-common PDCCH is not suitable.  |
| vivo | Not agree since gNB implementation should handle the GB in scheduling and UE just follows FDRA. |
| NTT DOCOMO | We don’t agree with the proposal. gNB can handle the issue as multiple companies mentioned. |
| Spreadtrum | We don’t agree with the proposal. It has been agreed that the UE will receive the PDSCH as scheduled. Therefore, avoiding the scheduling of PDSCH in the guard band should be handled by gNB implementation.  |
| ITRI | UE will receive PDSCH as scheduled, so gNB should handle the FDRA properly. |

## COT duration indication/determination

**Q4: Do you agree that the reference for co-Duration-r16 is the first symbol of PDCCH where UE detects the DCI format 2\_0 (suggested by vivo), or the end of the slot where UE detects the DCI format 2\_0 (suggested by LG)?**

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| FL Note: The detailed wording can be discussed after 28 April, if technical consensus on the definition is achieved. |
| **Company** | **Comment** |
| Huawei, HiSilicon | After the last symbol of a PDCCH providing the DCI format 2\_0. |
| MediaTek | Agree that the reference for co-Duration-r16 is the first symbol of PDCCH where UE detects the DCI format 2\_0 |
| Nokia, NSB | We propose CO-duration applies from [first or last] symbol of PDCCH where UE detects the DCI format 2\_0. |
| LG Electronics | Support reference point for co-Duration-r16 as the end of the slot where UE detects DCI format 2\_0, for simplicity and commonality with remaining CO indication by SFI index field (i.e., w/o co-Duration-16) where SFI index at least provides one slot configuration. |
| ZTE, Sanechips | I agree with vivo’s suggestion that the reference for co-Duration-r16 is the first symbol of PDCCH where UE detects the DCI format 2\_0. |
| Samsung | Reference for co-Duration is the first or last symbol of PDCCH where UE detects the DCI format 2\_0. |
| Intel | Reference for co-Duration-r16 is the first symbol of PDCCH where UE detects the DCI format 2\_0 |
| Qualcomm | We prefer the first symbol. On the other hand, should this be the first symbol of the slot? In SFI, the reference symbol effectively is the first symbol of the slot. We don’t see any need to be different. The difference is not large anyway, consider DCI 2\_0 can only be configured in the first 3 symbols of the slot. The only difference is if DCI 2\_0 is configured in a search space not starting from the first symbol. |
| OPPO | It seems this issue is addressed by the RAN1 agreement Agreement:COT duration indicates remaining length from the beginning of the slot where the information is received* When a UE receives a COT duration indication with a given symbol being within the COT duration, the UE is not expected to receive a subsequent COT duration indication that indicates that symbol to not be within the COT duration.
 |
| Sharp | Agree with Qualcomm. The simplest way is that the reference is the beginning of the slot where UE detects the DCI format 2\_0, just like SFI.  |
| vivo | No large difference for beginning of slot or first symbol of PDCCH as QC indicates. Picking one to make spec clear is OK. To us, the first symbol of PDCCH is more suitable for the definition of remaining COT duration. |
| Ericsson | We support “from the first symbol of the PDCCH where UE detects the DCI 2\_0 …” |
| NTT DOCOMO | Either first symbol of the PDCCH or the beginning of the slot where UE detects the DCI format 2\_0 is OK |
| Spreadtrum | Either is OK to us |
| ITRI | Reference for co-Duration is the beginning of the slot where UE detects the DCI format 2\_0. |

**Q5: What is your view on the UE behaviour outside the CO duration?**

It may happen that remaining channel occupancy time indicated by *co-Duration-r16* is shorter than the number of slots for which SFI-index field provides corresponding slot formats, since the minimum number of slots for each SFI-index field is pre-defined based on the periodicity configured for associated search space set.

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| LG (Proposal #3): If a UE detects DCI format 2\_0 indicating remaining channel occupancy time shorter than the number of slots for which SFI-index field provides corresponding slot formats, the UE ignores slot format information corresponding to slots outside of gNB’s channel occupancy time.Sharp (Proposal 5): UE behaviour outside CO duration should be the same as for the case when the UE has not detected a DCI format 2\_0 providing a slot format.Qualcomm proposal: Maintain the Rel.15 behavior that the SFI indicated for a slot from different DCI 2\_0 are consistent. No spec change neededEricsson proposal: No specification change needed.  If CO duration and SFI-index field are configured for UE at the same time, and the indicated slot format indication exceeds the CO duration. The UE shall follow indication provided by SFI-index for slot formats that exceeds CO duration, however these slots are not treated as being within the CO.FL Note: Please also consider whether this should be a mandatory behaviour ("UE shall ignore…") or an allowed behaviour ("UE may ignore…"). |
| **Company** | **Comment** |
| Huawei, HiSilicon | UE shall ignore the slot formats in Slot format combination which is outside of COT duration, if provided. |
| MediaTek | Ignore the slot format indicated by DCI 2\_0 corresponding to the slots outside of gNB’s channel occupancy time |
| Nokia, NSB | We think that from DL configured transmissions point of view, outside of indicated COT, UE should follow behavior corresponding to SFI not detected and ignore SFI, i.e. monitor PDCCH and cancel configured DL transmissions. For the wording, we suggest to follow wording already used in 11.1, for example: “if the UE is configured by higher layers to receive PDSCH or CSI-RS in the set of symbols of the slot, the UE does not receive the PDSCH or the CSI-RS in the set of symbols of the slot” |
| LG Electronics | Support either of proposals since two proposals pursue the similar UE behavior. Between mandatory behavior (“UE shall ignore”) and allowed behavior (“UE may ignore”), we prefer mandatory behavior. |
| ZTE, Sanechips | It can be solved by UE implementation. If this case happen, UE can ignore slot format provided by SFI-index field. |
| Samsung | UE shall ignore a slot format for a set of symbols if the set of symbols are not within a remaining channel occupancy duration. |
| Intel | Agree with LGE’s proposal |
| Qualcomm | We don’t see a need to define such behavior. If SFI is longer than COT duration, and after the current COT, the gNB acquires the channel again, and sends SFI again with overlapping range with the previous SFI. In this case, we prefer the SFI on overlapping slots to be consistent. If gNB wants to have no SFI out of COT duration, it can pick a shorter SFI index.  |
| OPPO | We support the UE shall ignore, there should be a clear UE behavior so that there is no ambiguity between UE’s and gNB’s understanding |
| Sharp | For the symbols which is indicated as not being within a CO duration by DCI 2\_0, UE shall ignore slot formats for the symbols indicated in the same slot. Note that slot formats indicated by a later DCI 2\_0 for those symbols should not be ignored. |
| vivo | Need to clarify the motivation, i.e. is there any problem to make system broken without such UE behavior?  |
| Ericsson | No specification needed.If CO duration and SFI-index field are configured for UE at the same time, and the indicated slot format indication exceeds the CO duration. The UE shall follow indication provided by SFI-index for slot formats that exceeds CO duration, however these slots are not treated as being within the CO. The intended use case for above proposal is power saving. The gNB should be able to indicate that the COT extends e.g. only for 2 more slots but that the next X number of slots after the indicated CO duration are UL slots. This will allow the UE to skip all PDCCH monitoring or use for configure grant transmission validation. The power saving use case comes from the original motivation for the C-PDCCH in LTE-LAA which have similar purposes that the GC-PDCCH tries to achieve. |
| NTT DOCOMO | Agree with Sharp’s proposal. |
| Spreadtrum | Share the same view as Qualcomm and Ericsson |
| ITRI | Agree with Ericsson’s view about UE power saving. Out of a CO, there exist a time period that gNB may not provide any DL service due to LBT procedure. The gNB can indicate the number of slots after the CO duration are UL slots by SFI, this will allow the UE to skip all PDCCH monitoring. |