3GPP TSG-RAN WG2 #114 Tdoc R2-21xxxxx

Electronic meeting, May 19th – 27th, 2021

Agenda Item: 6.5.2

Source: Ericsson (rapporteur)

Title: [AT114-e][221][DCCA] Cell grouping CR

Document for: Discussion, Decision

# 1 Introduction

This document is to kick off the following email discussion:

* [AT114-e][221][DCCA] Cell grouping CR (Ericsson)

Scope:

* + - Discuss CRs for R16 NR-DC cell grouping based on online agreements.

 Intended outcome:

* + - Discussion summary in [R2-2106493](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2106493.zip) (by email rapporteur).
		- Agreeable CRs. Intermediate status of discussion will be checked during 2nd week Monday session.

 Deadline for providing comments, for rapporteur inputs, conclusions and CR finalization:

* + - Deadline for CR finalization: 2nd week Wed, UTC 1000

In the online session Wednesday 1st week, the following was agreed:

* Work offline to provide CRs for the NW-filtering solution.
* Email discussion [221] (Ericsson)
* Checkpoint Monday 2nd week. If several possibilities, can have show of hands to see which direction has most support.

This discussion document is to gather comments from participating companies on the CRs for introducing cell grouping for NR-DC.

# 2 Discussion

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

|  |  |
| --- | --- |
| Company | Delegate contact |

|  |  |
| --- | --- |
| Ericsson | stefan.wager@ericsson.com |
| Qualcomm Incorporated (Masato) | mkitazoe@qti.qualcomm.com |
| Apple Inc | naveen.palle@apple.com |
| MediaTek | Chun-fan.tsai@mediatek.com |
| Nokia | Jarkko.t.koskela@nokia.com |
| Convida | sunell.kai-erik@convidawireless.com |
| Intel |  Youn.hyoung.heo@intel.com  |
| Huawei, HiSilicon | wangrui@huawei.com |
| SoftBank | katsunari.uemura@g.softbank.co.jp |
| ZTE | liu.jing30@zte.com.cn |
| CATT | liangjing@catt.cn |
| Samsung | himke.vandervelde@samsung.com |
| T-Mobile USA | brett.christian@t-mobile.com |

Companies are requested to add their comments for each of the treated CRs of this email discussion in the boxes below.

## 2.1 Network based cell group filtering

Network based cell group filtering is described in:

[R2-2106017](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_114-e/Docs/R2-2106017.zip) Cell grouping for NR-DC Ericsson discussion LTE\_NR\_DC\_CA\_enh-Core

Based on the text proposal in Annex A, draft CRs for 38.331 and 38.306 introducing cell group filtering have been created and uploaded to the drafts folder (link).

### 2.1.1 General questions and comments

Companies are requested to provide their questions and comments on the CRs in the table below. Detailed comments can also be provided in the CRs themselves, if more feasible.

|  |  |
| --- | --- |
| Company | Questions/Comments |
| Qualcomm Incorporated | We should clarify the behaviour when requestedCellGrouping is not included in UE Capability Enquiry. The UE should report only FR1-FR2 NR-DC in that case.[Ericsson] Agree, this is same as for legacy behaviour. We can clarify in the field description of requestedCellGrouping that ”If this field is absent, UE shall only inlude band combinations for which it supports NR-DC with only FR1 bands in MCG and only FR2 bands in SCG.” |
| Apple Inc | Agree with Qualcomm’s comments. We do not want UE implementations to handle the high/flexible cell-grouping combinations for the case where the NW does not provide the cell grouping filtering. The UE would assume that NW supports only FR1-MCG and FR2-SCG DC.[Ericsson] Agree, see above.[Apple2] Thanks for confirming. This is important from UE perspective to reduce signalling burden. We would like to make progress to try and come up with a filtering solution and conclude this in this meeting. Pls see some responses/comments further below.In addition, we have some more comments:In the proposed CR example, MCG=[n1, n7, n41, n66] and SCG=[n78, n261], we wonder on the NW flexibility or practical deployment options keeping in mind the future extensions. We can always have a DC combination just with n1, n7, n41 and n66. Does this mean that NW does not support this? We are also not sure if NWs have deployments where certain bands are always not considered as PCells ( n78/n261 in this case). What if the NW intends to support PCell on every band? What would be put into SCG group?[Ericsson] From a network perspective, we believe just a few cell groupings will be sufficient to cover the different NR-DC deployments. Remember that NR-DC is for inter site deployments with relaxed backhaul. For co-sited deployments, CA can be used. So for n1, n7, n41, n66, those could all be co-located and use CA. Alternatively, n41 and n66 may be colocated with n261 and in that case a separate CellGrouping with MCG [n1, n7] and SCG [n41, n66, n261] could be added. But we do not expect a lot of different cell groupings inside one network. Note that the UE does not have to support all the bands listed in requestedCellGrouping. So looking at our example 1, the UE can report a BC with e.g. [n1, n7, n78], meaning that for that BC it supports MCG [n1, n7] and SCG [n78]. Also note that the cell grouping for NR-DC does not affect PCell placement for CA users. [Apple2] If the NW provides MCG=[n1, n7, n41, n66] and SCG=[n78, n261] and MCG=[n1, n7] and SCG=[n41, n66, n261], then from UE perspective, combining different MCG/SCG pairs can defeat the purpose of filtering, as it is essentially the same as NW providing bands n1,n7,n41,n66,n261 and asking UE to come-up with DC groupings. If we are to make better use of this, the number of MCG/SCG grouping should be short (4 or less). We tend to agree with Ericsson’s comment that a few cell-groupings will be sufficient from NW perspective in terms of deployment. Can NWs cover their deployment with 4 pairs? We also need to bring in sync/async deployment info in this. Pls see below for more comments on this.[Ericsson2] Can you explain what you mean with “combining different MCG/SCG pairs can defeat the purpose of filtering”? The purpose is not to combine different MCG/SCG pairs (I assume with MCG/SCG pair you mean a particular *CellGrouping* within requestedCellGrouping?). Those should be treated and indicated independently by the UE, and they represent different grouping of the network requested bands into MCG and SCG. Then based on this list of *CellGroupings*, the UE creates the list of its supported BCs, and for each UE reported BC, the UE indicates which of the requested cell groupings that are supported for that BC. This is not the same as band filtering, where network provides a list of bands and asks the UE to come-up with DC groupings. But I am maybe missing something here? Also, can NW have the same band in both MCG and SCG..(we assume for the future intra-band DC case). In which case, the savings would be diminished. [Ericsson] In Wednesday session we concluded cell grouping is only needed for inter-band NR-DC. If needed in future, separate capability could be added, so it may not affect this.[Apple2] It is our view (talking to our RAN4) that intra-band NR-DC is not practical and we are ok to come back to this in future. But honestly, any additions to the current NW filtering based cell-grouping (if agreed) for intra-band could complicate things, and we hope we never get to discussing this.[Ericsson2] Agree, but we think the same complications apply also to UE based cell group signalling.Also, in the above example, how should the UE assume about the support of sync/async on the provided filtering bands..? Should the UE reports both async and sync DC, even when the NW can only support one of async/sync (it is our view that NW has deployed a config of timing across/within bands, and it cannot change the timing for different UEs). So it would be very useful to provide this info. [Ericsson] For sync/async, the UE can use legacy *asyncNRDC-r16* capability to indicate whether it supports sync or async operation per BC. If the NW uses *requestedCellGrouping* filter to ask for certain (list of) cell grouping(s), the UE indicates in a BC which Cell Groupings it supports for that BC. If the UE would support cell grouping #1 for “sync” and “async” but cell grouping #2 only with “sync”, it can include the BC twice. In one instance it would indicate cell grouping #1 and *asyncNRDC-r16*. In the other it includes cell grouping #2 but omits the “asyncNRDC-r16”. Then as you say network filtering could be added to request UE support for async NR-DC, but it is not directly dependent on the solution for cell grouping signalling. [Apple2] Sorry, looks like there is a misunderstanding. Our intention is to have the NW inform about sync/async NW deployment, so that UE can choose the DC grouping capability separately for sync/async (as Ericsson commented above). Our proposal is as below:maxCellGroupings-r16 ::= 4 [[ requestedCellGrouping-r16 SEQUENCE (SIZE (1..maxCellGroupings-r16)) OF CellGrouping-r16 OPTIONAL ]]}CellGrouping-r16 :: SEQUENCE { MCG SEQUENCE (SIZE (1..maxBands)) OF FreqBandIndicatorNR, SCG SEQUENCE (SIZE (1..maxBands)) OF FreqBandIndicatorNR, syncOperation ENUMERATED {true} OPTIONAL}For each of the MCG/SCG pairs, the NW informs if the MCG AND SCG carriers operate in sync DC or not. The default assumption is that MCG and SCG are async, and all carriers within a CG are atleast slot-sync. This way, the UE knows that certain carriers are being operated in sync NR-DC and can only provide the sync DC grouping for these.In our example, we can see that if NW provides the below, then we can assume that carriers n1, n7, n41, n66, are all slot-sync atleast. And n78 and n261 are also slot-sync as well. MCG=[n1, n7, n41, n66] and SCG=[n78, n261]Now if n66 is also co-located with n261 such that NW provides the two below pairs of MCG/SCGMCG=[n1, n7, n41, n66] and SCG=[n78, n261] and MCG=[n1, n7] and SCG=[n41, n66, n261]can we assume that carriers n1, n7, n41, n66, n261 are all slot-sync atleast. And even n78 is synch with the rest of the carriers?[Ericsson2] Yes, if the network indicates syncOperation {true}. If not, then UE can assume that n1 and n7 are always slot synced, and same for n78 and n261. For n41 and n66, it depends in which cell group they are configured. In our view, the NW usually has a big deployments of carriers which are in sync and which are asynch, usually two groups of sync. So 1 pair of MCG/SCG is enough where the UE can assume that MCG carriers and SCG carriers are async across CGs, and carriers within CG are in sync. The NW would have to repeat the MCG/SCG pairs to provide UE with sync DC groupings (hence the optional *syncOperation* IE with in each MCG/SCG pair. Can we request views from companies on this? [Ericsson2] Ok, I see what you mean. Indeed the network could filter for sync/async support per requested *CellGrouping*. If others agree to this approach, we could update the CRs accordingly.So, if network provides *syncOperation* {true} for a *CellGrouping*, the UE includes BCs for which it supports the cell grouping with sync operation. If network does not provide *syncOperation*, the UE uses legacy *asyncNRDC-r16* capability to indicate whether it supports sync or async operation per BC. If the NW uses *requestedCellGrouping* filter to ask for certain (list of) cell grouping(s), the UE indicates in a BC which Cell Groupings it supports for that BC. If the UE would support cell grouping #1 for “sync” and “async” but cell grouping #2 only with “sync”, it can include the BC twice. In one instance it would indicate cell grouping #1 and *asyncNRDC-r16*. In the other it includes cell grouping #2 but omits the “asyncNRDC-r16”. If we understand correctly, the proposed CR allows NW to provide more than one such MCG/SCG grouping? If so, will the bands from each of the group will not overlap? If they do, how does the UE interpret the overlap? If the NW provide atleast some bands that are the samea cross the diff MCG/SCG sets, then we think that the saving might not be practical.[Ericsson] Correct, network can provide a list of CellGroupings, e.g. CG#0, CG#1 and CG#2. The UE then echoes back for each BC where it supports NR-DC which cell grouping it supports out of CG#0, CG#1, CG#2. In this way, each cell grouping is treated separately, as it reflects an individual configuration of the UE, and in that way we don’t see the issue of having one particular band, e.g. n7, represented in several requested cell groupings. But maybe you can explain the concern?It is our view that the future-proof signaling should be able to allow the NW to provide this filtering info for every capability enquiry message.[Ericsson] Yes, if the network wants to setup NR-DC with FR1 in both MCG and SCG, it has to provide the requestedCellGrouping. Otherwise UE will report only FR1-FR2 NR-DC.Maybe, instead of providing bands for MCG and SCG, NW can provide bands that operate with time-sync and bands without any time sync and UE can build DC combinations for sync/async based on this. This allows the flexibility on the NW to assign P(S)Cell to diff bands. [Ericsson] I think for sync/async, it needs to be coupled to the MCG/SCG relation. It is difficult to say for a single band whether it is sync or async, in relation to what? What would improve the flexibility for the network to assign P(S)Cell to diff bands would be to make the cell grouping MCG/SCG agnostic, as we had it in LTE-DC signalling. I.e. the network provides two lists cellGroup1 and cellGroup2, and each could then be configured either as MCG or SCG. But then we need to revert the agreement made last year to make cell grouping MCG/SCG explicit.[Apple2] Pls see our views on couping MCG/SCG with sync/async above. Hope we can compromise on this to progress.We also have other UE reporting options that can reduce the signaling size if UE has relations between bands (if band X in a CG, band Y cannot be in the same CG, band A can only be in the same CG as band X), and this sort of signaling can avoid comprehensive signaling (if UE can signal such relation for applicable DC combinations, based on the bands). |
| MediaTek | The major issue to the size of *maxCellGroupings*, which actually provide another kind limitation on the number of bands in NR-DC. We will discuss more in next question.[Ericsson] As we mentioned above, we expect only a few cell groupings will be needed per deployed network.Several other comments.<1> The UE behavior while the filter is not provided should be clarified. QC proposal is okay for us.[Ericsson] Agree, see our comment to QC. <2> The aspect on sync and async NR-DC is missing. We probably need more capability bit to indicate the NW that the UE support cell group #X with sync or async NR-DC operation (or both support).[Ericsson] Yes, see our comment above to Apple. <3> Does the “fallback” principle apply the requested cell group. Using example 1 - MCG=[n1, n7, n41, n66] and SCG=[n78, n261], does this implies that MCG=[n1, n7, n41, ~~n66~~] and SCG=[n78, n261] is supported (and requested) by the network ? In other words, Is the UE requested to report the cell grouping that result in removing one or more bands in MCG or SCG of this cell grouping?[Ericsson] Yes, the UE does not have to support all the bands listed in requestedCellGrouping. So looking at our example 1, the UE can report a BC with e.g. [n1, n7, n78], meaning that for that BC it supports MCG [n1, n7] and SCG [n78].<4> We assume that intra-band NR-DC is not within this scope. So, the bands in MCG will be different from the bands in SCG. (Otherwise, it would be super complicate)[Ericsson] Agree |
| Nokia | 1. Qualcomm proposal on UE handling when filter is not provided is fine

[Ericsson2] CR updated accordingly. 1. Asynchronous and Synchronous DC handling needs to be handled as well. Either UE provides both async and sync capability “bitmap or list” or then NW needs to explicitly request which one is of its interest. We would be fine to report both async and sync separately by UE corresponding to bands in the request.

[Ericsson2] See discussion and proposal from Apple above.1. In case NW makes the request for cell group for multiple bands and if UE does not supports only sub combinations is UE assumed to report those combinations. We assume this should be the case i.e. basically NW indicates bands on MCG and bands on SCG which are “used in the NW” and then UE reports all the combinations – even those that do not include all the requested bands.

[Ericsson2] Correct, the UE does not have to support all the bands in network requested *CellGrouping*. 1. Then if UE reports MCG of n1,n7,n41,n61 and SCG n78,n261 – does this mean UE also supports MCG of n1,n7,n41 and SCG n78,n261?

[Ericsson2] Yes, this follows normal fallback principle. Regarding intra-band NR-DC – We assume this does not need any solution.[Ericsson2] Agree. |
| Convida | *requestedCellGrouping-r16* is an optional extension and is missing a Need code. Our understanding is that the code should be N.MCG and SCG are introduced as fields in the *CellGrouping-r16* information element but they should be defined with lower-case letters, i.e. *mcg* and *scg*. Otherwise, the ASN.1 syntax is not correct, and the code will not compile. The same correction should be done in the *requestedCellGrouping* field description.TABS should be replaced with spaces in *supportedBandCombinationList-v16xy.*Comments on formalities:NR\_newRAT-Core is a Rel-15 work item but the CR is written towards Rel-16. TEI16 is a better work item code for this CR because Rel-16 CRs (other than Category A) cannot be included in Rel-15 work item CR packs for TSG RAN approval.The CR category is B (on the cover sheet) but Rel-16 is already frozen and Category B is prohibited to frozen Releases. Are there any reasons why Category F (essential correction) cannot be used?[Ericsson2] Thanks a lot for these corrections! It is good to get this right! Regarding your first comment, there is actually a dependency between *includeNR-DC* and *requestedCellGrouping,* where *requestedCellGrouping* can be included only if *includeNR-DC* is also included. So I added a field condition for *requestedCellGrouping*.The work item code was indeed wrong. It should be LTE\_NR\_DC\_CA\_enh-Core, i.e. Rel-16 DCCA, which is indeed frozen, so we should consider this a correction to NR-DC capabilities. |
| Intel | We wonder if one set of requestedCellGroupngs is efficient to different frequency deployment. For example, there could be NR-DC based on [n1, n7, n41, n66, n78, n261]. In other network deployment, there could be NR-DC based on [n2, n3, n8, n78, n261]. It is assumed that UE capability enquiry should not be frequently triggered depending on the different deployment considering signaling overhead. If we support different NR-DC configuration with one set of requestedCellGroupings, the bitmap size (or list) of supportedCellGrouping from UE side would be dramatically increased.In that sense, 2-D structure of requestedCellGrouping would be more desirable i.e. a set of requestedCellGrouping per interested band combination. We also assume that the *supportedCellGrouping* is indicated per band combination. [Ericsson2] Ok, so if I understand this correctly, your intention is to improve scalability by adding the possibility to have more than one *requestedCellGrouping?* So, in a network with only a few *CellGroupings*, e.g. 4-8, a single *requestedCellGrouping* could be provided, and thus the reporting overhead per BC limited to a bitmap of size 4-8. However, support for networks with more than 8 *CellGroupings* could be ensured by adding the possibility for network to provide also more *requestedCellGrouping,* with a corresponding *supportedCellGrouping* field per BC. If there is no overlap between reported BCs for the two *requestedCellGrouping,* the reported overhead per BC would then be less than if just a single *requestedCellGrouping* is used*.* But need for this will depend on whether the situation in your example where the list of bands supported is orthogonal is common or not. For this it would be good to have operator input. Also note that this applies only to the bitmap option. If list option is used, the overhead does not reduce with adding several *requestedCellGrouping*.  |
| Huawei, HiSilicon | We have the similar question/concern as Apple that if there is a limitation on the number of cell grouping options supported by network considering real deployment. In our understanding, this cell grouping UE capability is raised due to UE capability restriction, but from network side there should be no such restriction. For instance, if the gNB deploys multiple bands, it is possible that any band could be either in MCG or in SCG. In this case, if network assumes a UE may only support several cell grouping options, in order to obtain the UE capability then the network should request all options in the filter proposed here. This is quite similar with the current filter of interested band, and the UE anyway needs to indicate which options are supported one by one, then the UL signaling overhead is similar with LTE DC style approach, but adding more DL signaling overhead.[Ericsson2] As we have explained above, we expect only a few cell groupings from network point of view, i.e. which of the deployed bands that will operate as MCG and which as SCG. So, by filtering for these, it will considerably reduce the UE capability size. |
| SoftBank | We don’t think intra-band NR-DC is precluded from the scope. It is a practical scenario and would be deployed in the future. When the NW indicates the same band for MCG and SCG, we assume the UE can report only if all possible combinations are supported or RAN4 will define/restrict the cell grouping within the indicated band to be supported by the UE. For example, the NW indicates MCG [n3, n77], SCG [n77] and n77 has two non-contiguous bands (let’s say n77\_L and n77\_H). 1) The UE can report this combination only if both MCG [n3, n77\_L] + SCG [n77\_H] and MCG [n3, n77\_H] + SCG [n77\_L] are supported. 2) the UE can report if the UE supports the cell grouping defined by RAN4. But if majority companies don’t like to introduce this at this moment, we are OK to postpone it and discuss later. However, if RAN2 goes to the NW filtering, it is good to use it as a baseline for intra-band NR-DC case because unified solution is anyway preferred. [Ericsson2] As we mentioned earlier we think the same issue exists also for the LTE-DC style reporting using bands, as in the endorsed CRs. So in that sense it does not affect the decision on whether to use NW filtering or LTE-DC style signalling for NR-DC cell group signalling. |
| ZTE | Besides the concern on the limitation of maximum number of cell grouping (expressed by other companies), we also have the following questions/comments:1. From network(MN) perspective, how does MN know the band(s) deployed in SN nodes that may be used for SCG cells deployment? Does it rely on OAM? And whether it works for inter-vendor scenario?

[Ericsson2] Our understanding is that this issue is not specific to network cell group filtering solution, but is general for NR-DC, MN and SN need to be aware of the available bands.1. As we commented online, the reported “*supportedCellGrouping*” is incomprehensible to target cell during handover procedure. So should we forward the “requestedCellGrouping” configuration to target cell during handover procedure?

[Ericsson2] The UE will echo back the received filters from the network in *UECapabilityInformation*, so this would be covered if the cell grouping filter is included in *UE-CapabilityRequestFilterCommon*, as in the proposed CR.receivedFilters OCTET STRING (CONTAINING UECapabilityEnquiry-v1560-IEs) OPTIONAL,It is not desirable to do capability enquiry every time when UE enters RRC\_Connected, so RAN will store UE’s radio capability in CN, and retrieves the stored capability from CN when UE transmits from RRC\_IDLE to RRC\_Connected. For this filtered NR-DC capability, if we want to make it work, the UE should also feedback the *requestedCellGrouping* to network when it reports UE capability. (same as sending “*appliedFreqBandListFilter*”), so it will cause additional signalling overhead. [Ericsson2] As explained above, UE will echo back the cell group filter if included in *UE-CapabilityRequestFilterCommon.* The additional overhead is limited, since the *requestedCellGrouping* list is only signalled once per UE, not per BC. |
| CATT | 1. Limitation on the maximum number of cell grouping, see our comment on Q2.1.2
2. During handover, how can he target cell to know the reported “*supportedCellGrouping*”? if request every handover, there is still too much signaling overhead.

[Ericsson2] The UE will echo back the received filters from the network in *UECapabilityInformation*, so this would be covered if the cell grouping filter is included in *UE-CapabilityRequestFilterCommon*, as in the proposed CR.1. How to distinguish the sync and async case?

[Ericsson2] One solution is to add a network filter for sync/async operation as discussed above with Apple. If not provided, the UE can use *asyncNRDC-r16* to indicate the support per BC.1. Another concern as HW is whether there is a limitation on the supported number of cell grouping options in real deployment. If the gNB deploys multiple bands, and maybe any band could be either in MCG or in SCG, then network may need to request all options. In this case, the signaling overhead is even double than the LTE DC style.

[Ericsson2] We expect the number of supported cell groupings from network point to be limited. With regards to LTE-DC style, the signalling overhead in the endorsed CRs is already double compared to LTE-DC, since MCG/SCG is indicated explicitly. |
| Samsung | Some remarks:1. We understand that the proposal means that if UE reports fallback combinations, it will provide cell grouping info for each FB BC. We would like to understand if common view is that cell grouping support may be different for different FBs. E.g. for the example
	* FB1: MCG=[n1, n7, n66] and SCG=[n78, n261]
	* FB2: MCG=[n1, n7, n66] and SCG=[n261]
	* FB3: MCG=[n1, n7, n66] and SCG=[n78]

[Ericsson2] Actually in this example there is no need to signal the fallbacks in case network filtered for cell grouping MCG=[n1, n7, n66] and SCG=[n78, n261]1. We furthermore assume that normal fallback principles apply i.e. fallback only needs to be signaled if cell grouping would be different (if applicable).
2. We agree that when filter is not provided UE legacy reporting applies i.e. UE shall only include band combinations for which it supports NR-DC with only FR1 bands in MCG and only FR2 bands in SCG
3. We think it would be good to extend the request filter with a field indicating whether synchronous operation applies for MCG and SCG.

We assume that there is no need to introduce any signalling changes for intra-band NR-DC right now. |
| T-Mobile USA | Like Softbank, we don’t think intra-band NR-DC should be precluded from the scope. It is a valid scenario. We do note Ericsson comments. |

***Rapporteur summary****: Several aspects were raised regarding the proposed CRs. In particular the following aspects were discussed:*

1. *maxCellGroupings. See rapporteur suggestion in 2.1.2.*
2. *How to handle sync/async NR-DC? See new section 2.1.4.*
3. *How does signalling work for fallback combinations? Rapporteur assumes normal fallback principles apply, i.e. UE does not need to include fallback BCs if the supported cell grouping does not change. Note that a UE does not need to support all bands listed in a particular cell grouping filtered by the network. For example, if the network provides the filter MCG=[n1, n7, n66] and SCG=[n78, n261], the UE may indicate this cell grouping for BC [n1, n7, n78] to indicate that it supports MCG=[n1, n7] and SCG=[n78].*
4. *UE behaviour when requestedCellGrouping is not included. All companies agreed if requestedCellGrouping is not included, the UE only reports NR-DC support for BCs where it supports FR1-FR2 NR-DC. This has been captured in the requestedCellGrouping field description in the draft CR.*
5. *Intra-band NR-DC was also discussed. Two operators regard it as a relevant scenario that should be supported. Majority of companies consider that no capability signalling solution is needed for this. Note that this does not mean it intra-band NR-DC not supported, just that there is no need for capability signalling at this point. The RAN4 LS in R4 stated that ”* *In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view. This can be a default UE capability which means no need to indicate the cell grouping capability explicitly.” RAN4 further stated ”* *RAN4 thinks the support of these cases may be needed in the future depending on the operator’s demands, and the UE capability signaling needs to be extended at that time.” Based on this, we can conclude the same as [Post113e-bis][222] Cell grouping for NR-DC (Nokia) that there is no need for separate for intra-band NR-DC capability.*
6. No need for separate intra-band NR-DC capability.

### 2.1.2 Size of *maxCellGroupings*

One open issue that needs to be solved is to decide a suitable value for *maxCellGroupings* in the CR, i.e. what should be the maximum number of cell groupings that the network can filter for. The size affects the size of *supportedCellGrouping*, which is signalled as part of UE capability for each supported band combination. The target should be to not exceed the overhead per BC created by the LTE-DC cell group signalling approach, for which the cap of 5 bands created a bitmap of max 30 bits. Note that

Companies are requested to provide their input on the size of *maxCellGroupings* in the table below.

|  |  |  |
| --- | --- | --- |
| Company | Size | Motivation |
| Ericsson | 4 or 8 | Given that the UE does not need to support all bands in *requestedCellGroupngs,* we expect not many cell groupings will be needed. We added some examples in the field description to illustrate this. Mostly a single cell grouping should be sufficient, but the list could have max size of 4 or 8.  |
| Qualcomm Incorporated |  | It is indeed important we have good visibility on the value of ” maxCellGroupings-r16”. This essentially tells if the network filtering scheme is more efficient than explicit signalling of Cell Grouping combinations by the UE.We would like to rely on network vendors and operators on the exact value. But the principle should be that it is advisable that network includes Cell Grouping combinations used in the entire operators network rather than Cell Grouping used in the gNB. |
| Apple |  | Pls see our comments to Q2.1.1 |
| MediaTek |  | We are not sure if small number of cell groups does work as it will translate to deployment limitation. This is just another kind of 5-band limitation. For a **single** band combination with 6 bands (e.g. {n1, n7, n41, n66, n78, n261}), there is 62 possible way of grouping. Example 1 is just one of them. And we have much more combinations from other BC with 6 bands, or with 7 bands, etc. In theory, the size *maxCellGroupings* could be large. But large number implies that the capability size does not really reduced.[Ericsson] Yes, in theory the number of cellGroupings can be very large, but in practice we expect it to be quite limited. See our comments above in 2.1.1. Also, as explained above the UE does not have to support all the bands listed in requestedCellGrouping. This means that the network does not have to provide explicit filters for all band combinations, but can include many bands within each cell group, which can map to several band combinations reported by the UE.It could only work if operator/network vendors confirm that extremely few combinations will be used in the field. |
| Nokia |  | We agree with Qualcomm comment cell grouping combinations needs to support all the reasonable groupings used in the NW – If we would only consider one cell grouping requirement then handover handling would be cumbersome as NW would always need to fallback to least capability approach. Taking this into account It seems very unlikely that a operator will use many different band combinations within a reasonable area – country/state i.e. within coverage of operator requiring no roaming is very likely to only possess very limited set of combinations.  |
| Intel | (2 or 4 or 8)xN | As we commented to Q2.1.1, one set of CellGrouping would not be desirable and 2-D structure is more preferred. We should also discuss how many band combinations (i.e. “N”) is suitable to avoid frequent update of UE capability signaling based on different frequency deployment. We tend to agree with Nokia on that it is unlikely to use many different band combinations. However, it is hard to decide the exact number as signaling should be more future proof.  |
| Huawei, HiSilicon |  | We still think from signaling point of view, it should allow network request the capability of any cell grouping if there is no restriction on network deployment. Otherwise, if network supports all options, but can only request some of them, then it may mismatch the real supported options of the UE.  |
| SoftBank |  | Agree with Huawei. |
| ZTE |  | Smaller value will cause frequent capability enquiry, so larger value should be pursued. But we agree with others, it is hard to decide an exact number right now and the signalling should be more future proof.  |
| CATT |  | The exact number may be different depend on the network deployment, i.e., the number of supported deployment frequency bands. Too small number may mismatch the real supported NR-DC options of UE, or cause frequent capability exchange between UE and NG-RAN. Possible way is a large number. |
| Samsung |  | As indicated previously, the number of entries largely determines the efficiency of the scheme. Given diverse views on the required number, it seems difficult to judge at present |
| T-Mobile USA | 16 | We suggest 16 considering mix of LTE and NR bands and considering same RF unit can support several bands; e.g. B71 and B12 in same unit. |

***Rapporteur summary****: So far companies did not have clear views regarding exact size of maxCellGroupings. Concerns were raised towards limiting the max value too much, which would limit network deployment options for used bands.*

*This was also discussed in the Web Conf 2nd week Monday session, where it was discussed that if supportedCellGrouping is of type variable bitmap, the UE capability overhead may not be directly dependent on the value of maxCellGroupings, but rather the number of requested cell groupings in requestedCellGrouping. This means that maxCellGroupings can be somewhat more generous to be future proof. However, as shown in the table in section 2.1.3 rapporteur summary, there is still an impact from maxCellGroupings on the encoded size of supportedCellGrouping. Thus, also with variable size bitmap, there is still a tradeoff between flexibility and overhead when selecting the value for maxCellGrouping. Considering this and the discussion so far here and in the online session, rapporteur considers that maxCellGroupings=16 can be a suitable compromise between flexibility and overhead.*

1. The size of maxCellGroupings=16.

Companies having concerns with the above value are requested to include their view of a suitable max value in the table below, along with motivation.

|  |  |  |
| --- | --- | --- |
| Company | Size | Motivation |
| T-Mobile USA | 16 | We suggest 16 considering mix of LTE and NR bands and considering same RF unit can support several bands; e.g. B71 and B12 in same unit. |
| MediaTek | 16 | We are okay with size=16 |
| Huawei, HiSilicon |  | If the network supports 5 bands and the deployment has ideal backhaul, this method requires 30 filters to get all the UE supported combinations. Otherwise, network capacity might be restricted only because the network will miss some supported combinations.**This means that this method is not scalable for network deployments with ideal backhaul and 16 already create problems with 5 bands.**If we want something future proof, we should at least have **10 bands**, for which the LTE style method takes 1022 bits, i.e. around 128 bytes. This is significant but still a small portion of UE capability size, so it could solve the problem for up to 10 bands.As it is urgent for operators, we suggest adopting now the LTE style reporting for up to 10 bands and take time to design a better filtering method for more than 10 bands. |
|  |  |  |
|  |  |  |

### 2.1.3 *supportedCellGrouping* as list or bitmap

Another open issue may be whether *supportedCellGrouping* should be encoded as list or bitmap in ASN.1. In the current draft CR it is encoded as list, which means the size will be variable depending on the number of *requestedCellGroupings* supported by the UE:

CA-ParametersNRDC-v16xy ::= SEQUENCE {

 supportedCellGrouping SEQUENCE (SIZE (1..maxCellGroupings)) OF INTEGER(0..maxCellGroupings-1) OPTIONAL

Alternatively, it could be encoded as a bitmap, where each bit position points to a certain entry in the *requestedCellGroupings* list, e.g.:

CA-ParametersNRDC-v16xy ::= SEQUENCE {

 supportedCellGrouping BIT STRING (SIZE(maxCellGroupings)) OPTIONAL

The benefit with the bitmap format is the more compact size through the bitmap representation, but the drawback it that the size is constant, i.e. it is the same regardless of the number of *requestedCellGroupings* provided by the network. Assuming though that network and UE vendors are aligned in what cell groupings that are supported, it can be expected that the UE normally supports all (or at least most of) requestedCellGroupings, and then bitmap could be more efficient.

Companies are requested to provide their input on the encoding of supportedCellGrouping in the table below.

|  |  |  |
| --- | --- | --- |
| Company | List or bitmap | Motivation |
| Ericsson | bitmap? | We originally had the list, but assuming UEs support all or most of cell groupings requested by the network the bitmap may be more efficient. |
| Qualcomm Incorporated |  | Depends on the value of maxCellGroupings-r16. Bitmap looks fine if it is in the range of 10 combinations. |
| Apple | Depends | we think this can be resolved once the open items are addressed in Q2.1.1. |
| MediaTek | Depends | We should design the size of *supportedCellGrouping* first. |
| Nokia | Both will work | No strong view – both approaches will work. Based on earlier questions probably resolvement this question is easy to answer once we know *supportedCellGrouping* size.  |
| Convida | There is no difference between lists and bitmaps | It does not make any difference with respect to efficiency if it is defined as a list or bitmap. If the list has always the same size, SIZE can also be defined to be fixed where the list size is inferred from the syntax. Hence, the following encoding should be as compact as a bitmap, i.e.CA-ParametersNRDC-v16xy ::= SEQUENCE { supportedCellGrouping SEQUENCE (SIZE (~~1..~~maxCellGroupings)) OF INTEGER(0..maxCellGroupings-1) OPTIONALbecause* SIZE (maxCellGroupings) is encoded with 0 bits and
* INTEGER (0..maxCellGroupings-1) has the same number of code points and the same encoding size as BIT STRING (SIZE(maxCellGroupings)).

So, the key question is if the list size needs to be defined as a value range or fixed value.We have a slight preference for a list definition because it is more human readable than a bitmap. |
| Intel | No strong preference | If the maxCellGroupings per BC is limited to 2-4, either BIMAP or list can be working.  |
| Huawei, HiSilicon | Depends | No big difference. The former two issues are more critical. |
| SoftBank |  | There is no big difference. |
| ZTE | Depends | In fact, TS 38.331 has defined BIT STRING with variable length, see below example: measurementSlots BIT STRING (SIZE (1..80)),But this can be discussed after critical issues are solved.  |
| CATT | Depends | Before we discuss the details, better to solve the above concerns for the filter method. |
| Samsung | Depends | At present it seems somewhat difficult to predict which format will in real life be most optimal |

***Rapporteur summary:*** *Most companies had no strong view on whether the encoding is done with list or bitmap and that this can be solved after the size of maxCellGroupings is decided. One company pointed out that a variable size BIT STRING could be used:*

CA-ParametersNRDC-v16xy ::= SEQUENCE {

 supportedCellGrouping BIT STRING (SIZE (1..maxCellGroupings)) OPTIONAL

}

*Rapporteur notes there can indeed be a benefit of using variable size bitmap for the case where less than maxCellGroupings is used. However, flexibility usually comes with overhead. Below is a table showing how the encoded size of the supportedCellGrouping field using flexible bitmap depends on the number of requested cell groupings for different values of maxCellGroupings. As can be seen, even with variable bitmap, the value of maxCellGroupings has an impact on the encoded size of supportedCellGrouping. A good compromise of maxCellGroupings could be 16, for which 1-3 cell groupings can be indicated in supportedCellGrouping using one octet, which is less than what would be required with a fixed bitmap (2 octets when maxCellGroupings=16).*

*maxCellGroupings 64 32 16*

*Encoded size Number of requested cell groupings*

*1 byte 1 1-2 1-3*

*2 byte 2-9 3-10 4-11*

*3 byte 10-17 11-18 12-16*

*Thus, assuming we can agree on maxCellGroupings=16, rapporteur proposes the use of flexible bitmap for the encoding of supportedCellGrouping.*

1. *supportedCellGrouping* is defined as variable size bitmap.

Companies having concerns with the above proposal are requested to include their view of a suitable field type for supportedCellGrouping in the table below, along with motivation.

|  |  |  |
| --- | --- | --- |
| Company | Field type | Motivation |
| Apple | No strong preference  | With fixed size, it can help UE budget the container sizes while composing the UE capability response. But with size 16, we are ok with variable bitmap as well.  |
| MediaTek | No strong view | With size 16, fixed or flexible bitmap does not make too much difference. |
| Qualcomm Incorporated |  | We think this is somewhat related to the UE capability filtering discussion below. If we come to a solution where the UE has to indicate the support for sync and/or async per cell group, it may be better to introduce a list containing cell group ID as follows.supportedCellGroupingList-r16 SEQUENCE (SIZE (1..maxCellGroupings-r16)) OF supportedCellGrouping-r16supportedCellGrouping-r16 :: SEQUENCE { cellGroupID INTEGER(1.. maxCellGroupings-r16) operationMode ENUMERATED {syncOnly, syncAndAsync}}[Apple2] Please see our view in Q2.1.4 as a response to MediaTek’s comments, which are similar to this. |
|  |  |  |
|  |  |  |

### 2.1.4 Handling support for sync/async NR-DC

One topic raised in 2.1.1 is how to handle UE support of sync and async NR-DC operation. Rapporteur notes that baseline for indicating support for sync or async NR-DC is to use the legacy asyncNRDC-r16 capability indication, signalled per BC. If the NW uses *requestedCellGrouping* filter to ask for certain (list of) cell grouping(s), the UE indicates in a BC which Cell Groupings it supports for that BC. For instance, if for a BC the UE would support cell grouping #1 for “sync” and “async” but cell grouping #2 only with “sync”, it can include the BC twice. In one instance it would indicate cell grouping #1 and asyncNRDC-r16. In the other it includes cell grouping #2 but omits the “asyncNRDC-r16”.

***Question 1: Do companies agree the above baseline for handling support of sync vs async NR-DC?***

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Motivation |
| Apple | No | We want to avoid UE repeating the same BC again to report sync vs async. We think this can be avoided, as in our view the proposed MCG/SCG pair can provide the NW’s deployment on the support of sync or async variant, and then the UE provides the supported sync or async that is relevant to the NW. In other words, we do not see a case where for a particular NR-DC combination, the NW can support both sync and async (as the cell timing does not change once configured). So it is not necessary for the UE to report both if the NW can only use one. Also, the proposed CR already mentions that the UE can assume all the carriers in one CG can form CA (stating that the carriers in a CG are atleast slot-aligned). So it’s only about whether the carriers across CG pair are operating in sync or async manner from NW deployment. This can allow the UE to remove not needed DC combinations. Pls note, the UE’s cell grouping support can change depending on whether the UE supports sync DC or async DC.  |
| MediaTek | No | In general, we should avoid repeat same BC twice.It would be more straightforward if the UE just provides its supported cell group for sync and async operation respectively. Sample code below. CA-ParametersNRDC-v16xy ::= SEQUENCE { supportedCellGroupingSync BIT STRING  (SIZE (1..maxCellGroupings)) OPTIONAL supportedCellGroupingAsync BIT STRING  (SIZE (1..maxCellGroupings)) OPTIONAL}[Apple2] We are hesitant in making the UE inform the NW about sync and async support for a DC combination in a single IE sequence. This implies that the UE has same capabilities for sync and async DC. Which is not the case usually (esp in the UL support like PUCCH placement etc..). Besides, we can have future capabilities (esp from RAN4 like Tx related) where there can be differences between sync and async, and above signalling might not work then. More than likely the UE would have repeat the DC combination (infact the BC) again and report the corresponding sync/async capability. And in our view, we want to make sure that the NW actually supports both sync and async in a larger geographical area (?).We much rather prefer that the NW provide the interest of sync or async for the UE to report the corresponding capability. In the remote cases where both sync and asynd are needed, the NW can request that in a separate MCG/SCG pair..? That way we will have additional signalling for the corner case which is triggered with explicit NW request. |
| Qualcomm Incorporated | No | Agree with Apple that we should avoid repeating the same BC only for the purpose of indicating different sync/async capability.But we think it is possible that the network supports sync in one region and async in another region, within PLMN. So reporting both sync and async capabilities is useful.[Apple2] As mentioned above, we view this as a remote case and adding NW additional request for remote case than having UE report for both sync/async can be more efficient. Also as commented above, using same BC/DC for both sync/async capabilities might not be possible always, and we want to avoid UE repeating BCs unless NW is actually interested in sync/async for the same MCG/SCG pair. |
| Ericsson | Yes | We think using the legacy async-NRDC capability to indicate the support for async NRDC per BC is the baseline. Then network filtering can be added on top to avoid the concerns with duplication of BCs from the UE, for the cases when network is only interested in the sync or async support. But as also mentioned by Qualcomm, the network support for sync / async may vary in different region.  |
|  |  |  |

Then as extension to the above, network filtering could also be added to allow network to filter out BCs for which the UE supports only sync or only async NR-DC, but it is not directly dependent on the solution for cell group signalling. As shown above, cell group filtering works also without filtering for sync or async NR-DC operation.

In the 2.1.1 discussion, it was proposed that network filter for sync NR-DC operation could be added per requested *CellGrouping* in *UE-CapabilityRequestFilterCommon*:

CellGrouping-r16 :: SEQUENCE {

 MCG SEQUENCE (SIZE (1..maxBands)) OF FreqBandIndicatorNR,

 SCG SEQUENCE (SIZE (1..maxBands)) OF FreqBandIndicatorNR,

 syncOperation ENUMERATED {true} OPTIONAL

}

However, before deciding to introduce support for network filtering for sync/async NR-DC support, there are a couple of further aspects that need to be considered. Firstly, it is not clear whether filtering is needed per requested CellGrouping or whether it could be per UE? Second, should there be a filter only for synchronous NR-DC operation or should there also be a filter for asynchronous NR-DC operation? The purpose of such filter would be to allow the network to filter out BCs for which the UE supports only synchronous NR-DC operation or asynchronous NR-DC operation. Filtering for async NR-DC only could be effective for networks to filter out BCs for which the UE supports async NR-DC, assuming that this list may be shorter than the list of BCs for which the UE supports sync NR-DC. Companies are invited to include their input on network filtering for sync or async NR-DC in the table below.

***Question 2: Do companies think network filtering for UE sync/async operation should be added? If so, please specify whether filtering should be added per requested CellGrouping or per UE? Should the filter be added for synchronous NR-DC and/or asynchronous NR-DC?***

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Motivation |
| Apple | Filtering based on sync/async is already partly implied with the proposed CR | And this filtering is partly implied and is per-CG pair. Using the same example from the CR, if the NW provides CG pair as MCG=[n1, n7, n41, n66] and SCG=[n78, n261], then UE can assume that n1,n7,n41,n66 are in sync operation, and n78, n261 are in sync operation. If the UE supports n41\_n261 only in async DC, then it helps to know if the NW supports the CG pair MCG=[n1, n7, n41, n66] and SCG=[n78, n261] in sync or async DC. In our view, if the NW supports MCG=[n1, n7, n41, n66] and SCG=[n78, n261] as async, then n78/n261 do not operate in a sync manner in with any bands of n1/n7/n41/n66. |
| MediaTek | No | Adding this sync operation in the band filtering make the overall design complicate. We don’t not see the need of this. As commented in previous question, a simple way to do this code be.CA-ParametersNRDC-v16xy ::= SEQUENCE { supportedCellGroupingSync BIT STRING  (SIZE (1..maxCellGroupings)) OPTIONAL supportedCellGroupingAsync BIT STRING  (SIZE (1..maxCellGroupings)) OPTIONAL}[Apple2] We are hesitant in making the UE inform the NW about sync and async support for a DC combination in a single IE sequence. This implies that the UE has same capabilities for sync and async DC. Which is not the case usually (esp in the UL support like PUCCH placement etc..). Besides, we can have future capabilities (esp from RAN4 like Tx related) where there can be differences between sync and async, and above signalling might not work then. More than likely the UE would have repeat the DC combination (infact the BC) again and report the corresponding sync/async capability. And in our view, we want to make sure that the NW actually supports both sync and async in a larger geographical area (?).We much rather prefer that the NW provide the interest of sync or async for the UE to report the corresponding capability. In the remote cases where both sync and asynd are needed, the NW can request that in a separate MCG/SCG pair..? That way we will have additional signalling for the corner case which is triggered with explicit NW request. |
| Qualcomm Incorporated | Yes | Per Cell Group.Since async is easier for the network implementation, there could be the case where the network is interested in the cell grouping UE capability only if the UE supports async? Another case is not to bother requesting async, because the network is kind enough to support sync NR-DC across the entire network.Then the network request can have the following indications; {sync-only, async-only, either}. And in case of “either”, the network needs to know which operation(s) the UE supports. |
| Ericsson | Yes | We agree with Qualcomm that the filter could be per cell group, and there could be separate filters for syncOnly and asyncOnly. Then absence of the filter or the “both” means the UE needs to indicate whether sync or async is supported. But we think the filtering for sync/async is something we can add later and is not needed for agreeing the CRs.  |
|  |  |  |

***Rapporteur summary:*** *Not many companies participated in this part of the discussion, but based on the input received so far, it seems difficult to conclude the handling of sync/async NR-DC. If companies are not able to agree the baseline in question 1, it seems we will not be able to agree solution and we need to continue the discussion later.*

*Considering that RAN2 was tasked by RAN to agree a solution and CRs for cell grouping capability signalling in this meeting, and that the CRs discussed in this offline are now in decent shape, rapporteur would like to try the following proposals to be discussed online:*

1. Legacy *asyncNRDC-r16* capability indication is used by the UE to indicate support for asynchronous NR-DC per BC, for the included Cell Groupings.
2. The CRs in R2-2106512 and R2-2106513 are agreed (possibly after 1 week email discussion for final check).

If above proposals 4 and 5 cannot be agreed, CRs are not agreed, and RAN2 needs to continue discussion on the handling of sync and async NR-DC.

# Conclusion

Rapporteur would like to thank all companies participated in the discussion. Based on the discussion the following is proposed:

[Proposal 1 No need for separate intra-band NR-DC capability.](#_Toc72952787)

[Proposal 2 The size of maxCellGroupings=16.](#_Toc72952788)

[Proposal 3 *supportedCellGrouping* is defined as variable size bitmap.](#_Toc72952789)

[Proposal 4 Legacy *asyncNRDC-r16* capability indication is used by the UE to indicate support for asynchronous NR-DC per BC, for the included Cell Groupings.](#_Toc72952790)

[Proposal 5 The CRs in R2-2106512 and R2-2106513 are agreed (possibly after 1 week email discussion for final check).](#_Toc72952791)