[RAN94e-R18Prep-27] CA/DC enhancements - Version 0.0.5
RAN

3GPP TSG RAN Meeting #94e **RP-212687**

Electronic Meeting, Dec. 6 - 17, 2021

Title: Moderator's summary for [RAN94e-R18Prep-27] on CA/DC enhancements

Source: Moderator (ZTE, RAN2 VC)

Agenda Item: 8A.1

Document for: Discussion and decision

1 Scope of the discussion on Rel-18 CA/DC enhancements

This email discussion on possible Rel-18 CA/DC enhancements starts from the conclusions of the previous round, summarized in RP-211664 and copied below.

——————————- From RP-211664 (start) ——————————————

Proposal 3 (non-controversial): *For CA/DC enhancement, continue RAN discussions on the following potential enhancements to determine whether or not to include as part of Rel-18.*

- *Cross carrier operation enhancement (RAN1, RAN2)*
  - *For example, multi-cell scheduling with single DCI, FR2 SCell scheduling for PUSCH on FR1 PCell, cross carrier HARQ*
- *Multi-RAT Multi-Connectivity, MR-MC (RAN2, RAN3, RAN1):*
  - *For example, enhanced simultaneous UL transmissions and DL receptions with multiple cell group management*
- *FR2-specific aspects (RAN2, RAN4)*
  - *For example, SCell/SCG setup delay reduction with early measurement enhancement*

——————————- From RP-211664 (end) ——————————————-

However, based on RAN#93-e plenary decision, reflected in RP-212608, the mobility related CA/DC enhancements should be discussed in the mobility enhancements thread.

Regarding "MR-MC" (Multi-RAT Multi-Connectivity), the following two different aspects were basically discussed in the CA/DC enhancements thread in the past:

1. ”MR-DC (Multi-RAT Dual-Connectivity) with selective activation of the cell groups”: multiple cell groups can be (RRC) configured for a UE, but only (up to) two cell groups can be active simultaneously
2. ”MR-MC with more than two active cell groups”: e.g. three or more cell group can be active simultaneously (at least in the DL)

The first aspect (MR-DC with selective activation of the cell groups) is related to mobility, as the two cell groups which are active at a time could be typically related to the UE movement.

On the other hand, the second aspect (MR-MC with more than two active cell groups) seems to be an independent CA/DC enhancement, unrelated to mobility.

Hence, the intended work-split is to include only the ”MR-MC with more than two active cell groups” in the CA/DC enhancements thread and leave the ”MR-DC with selective activation of the cell groups” to the mobility enhancements thread.

Regarding ”SCell/SCG setup delay reduction with early measurement enhancement”, since the intention is to reduce the latency of SCell/SCG setup after mobility, it seems that this can be discussed in the mobility enhancements thread as well.

Finally, RP-211664 also lists another proposal that, as per RAN#93-e plenary decision in RP-212608, should be discussed in the CA/DC enhancements thread, as shown below.

———————————- *From RP-211664 (start)* ————————————————

Proposal 4 (non-controversial): For flexible spectrum integration, continue RAN discussions to converge on the need for introducing a new framework in addition to the existing CA framework.

——————————— *From RP-211664 (end)* ————————————————

In conclusion, the email discussion on the possible Rel-18 CA/DC enhancements is expected to focus at least on the following aspects:

1. Cross carrier operation enhancement (RAN1, RAN2)

- *For example, multi-cell scheduling with single DCI, FR2 SCell scheduling for PUSCH on FR1 PCell, cross carrier HARQ*

2. MR-MC with more than two active cell groups (RAN2, RAN3, RAN1)

3. Flexible spectrum integration (RAN1, RAN2)

2 Initial round

2.1 Cross carrier operation enhancements

Regarding the proposal for cross carrier operation enhancements, companies are invited to provide their view on the specific enhancements suggested so far (e.g. including justification why they are considered as needed/not needed):

- multi-cell scheduling with single DCI
- FR2 SCell scheduling for PUSCH on FR1 PCell
- cross carrier HARQ

Feedback Form 1:

1 – Ericsson LM

Multi-Cell scheduling with a single DCI: We are fine to include this objective in the WID. Intra-band CA and FR2 cases should be covered.

FR2 SCell scheduling for PUSCH on FR1 PCell: In general we support SCell FR2 scheduimgn PCell in FR1 and think this is an important objective. We think this should be applicable both for PDSCH and PUSCH.

Cross-carrier HARQ: This has been discussed for a long time (10 years?). Every time, it has been concluded to not introduce this due to too high complexity while too low gain. We don't think anything significant has changed since last time we discussed this.

2 – HuaWei Technologies Co.

Regarding **multi-cell scheduling with single DCI**, it has been thoroughly studied in R17 with comprehensive simulation evaluations by companies, and it is observed that it can lead to reduced PDCCH blocking probability, reduced CCE overhead, system throughput improvement, and reduced power consumption obviously. Thus, it should be specified in Rel-18 and we understand this can be applied to both intra-band/inter-band and FR1/FR2 cases.

Regarding **FR2 SCell scheduling for PUSCH on FR1 PCell**, we think it is not a common case since PDCCH resources in multiple FR1 carriers are typically available. There is no strong motivation to put PDCCH on FR2, especially considering the coverage of the scheduling carrier on FR2 may be much worse than the scheduled carrier on FR1. We do not support this item.

Regarding **cross-carrier HARQ**, NR URLLC poses high requirements for latency and reliability, e.g., 1ms. XR traffic has the similar requirements. In this case, cross carrier HARQ can bring the benefits of latency reduction for various applications. For example, transmission latency on the TDD band is limited by the D/U configuration, the gain is obvious if re-transmissions can be performed on another complementary TDD band or FDD band. Thus, we support to consider cross-carrier HARQ in Rel-18.

3 – Samsung R&D Institute UK

Multi-cell scheduling with single DCI: We suggest to add a clarification of "for the scenarios with > 2 cells" in order to avoid repeating Rel-17 discussions.

FR2 SCell scheduling for PUSCH on FR1 PCell: There is no apparent need/deployment scenario to have FR2 SCell scheduling for PUSCH on FR1 PCell.

It has at least the underlying assumptions that (a) an operator has no FR1 spectrum for NR only, (b) the FR2 coverage is large (e.g. within range of the FR1 coverage, including for providing Type-3 CSS), and (c) UEs have FR2 capability. There is no apparent need to address the combination of the above conditions (and there are also other restrictions such as the number of UEs that can be scheduled per slot in FR2). On a secondary level, it is strange to limit such scheduling to PUSCH.

Cross carrier HARQ: It will have substantial MAC impact and is not motivated for CA applications or CA capable UEs.

4 – LG Electronics Inc.

Multi-cell scheduling with single DCI

we don't see the essentiality to be pursued in Rel-18 on top of the existing tools sufficient to address PDCCH blocking/overhead such as multi-PDSCH/PUSCH scheduling introduced in Rel-17 60GHz WI and Scell-to-Pcell cross-CC scheduling introduced in Rel-17 DSS WI. Therefore, it is to be considered with low priority for Rel-18.

FR2 Scell scheduling for PUSCH on FR1 Pcell

As companies already commented, the motivations and scenarios requiring the feature essentially seems unclear. Thus, it is also to be considered with low priority for Rel-18 unless clear motivations/scenarios are provided by the proponents.

Cross-carrier HARQ operation

cross-carrier HARQ has been discussed in RAN2 for many times, starting from LAA in LTE. However, it has been progressed at all because of its complexity, which comes from the fact that it breaks the principle of independent HARQ buffer management. In the meanwhile, cross-carrier HARQ is to enable a transmission switched from e.g., one cell to another cell, which now can be realized by PDCP Duplication because the same packet can be distributed over different cells. Therefore, we don't see a gain of cross-carrier HARQ on top of PDCP Duplication.

5 – Lenovo (Beijing) Ltd

- For CA enhancement, we support multi-cell scheduling via a single DCI including both DL scheduling and UL scheduling and carriers in FR1 and FR2 as well as licensed carrier and unlicensed carriers. Furthermore, to guarantee a reasonable DCI payload size and keep "3+1" DCI size budget, we think two-stage DCI for multi-cell scheduling should be considered in Rel-18 as two-stage SCI in Rel-16 V2X.
- For FR2 SCell scheduling for PUSCH on FR1 PCell, we think the motivation is quite clear in order to provide more control resource on FR2 SCell for scheduling PUSCH on FR1 PCell.
- For cross-carrier HARQ transmission, we don't see the need to specify this in RAN1 and we also have strong concern on RAN2 standard impact in terms of implementation complexity.

6 – Spreadtrum Communications

For **multi-cell scheduling with single DCI**, we are supportive to discuss it in Rel-18. It was widely discussed in Rel-17 DSS and benefits including PDCCH blocking rates, system throughput were observed.

For **FR2 SCell scheduling for PUSCH on FR1 PCell**, we are fine with it. It is an extension of Rel-17 DSS, which only support sSCell scheduling in FR1. PUSCH and PDSCH can both in the scope if possible.

For **cross carrier HARQ**, we do not think it is a high priority objective. Because cross carrier HARQ has been studied for a lots of topics, we still do not find a strong need for it. More clarification and use cases can be elaborate more probably.

7 – CATT

Multi-cell scheduling with single DCI: We support the objective given the benefits shown in previous studies.

FR2 SCell scheduling for PUSCH on FR1 PCell: As commented by other companies, the scenario/use case/benefit need to be justified.

cross carrier HARQ: Considering the complexity vs. gain, we do not support the objective.

8 – China Mobile Com. Corporation

Multi-Cell scheduling with a single DCI: This objective is ok to us and can be applied to intra-band/inter-band and FR1/FR2 cases.

FR2 SCell scheduling for PUSCH on FR1 PCell: we share other companies view that the motivation and scenario need to be clarified.

cross-carrier HARQ: we think this objective can be considered with low priority considering the complexity and benefits.

9 – InterDigital Communications

- We support multi-cell scheduling using single DCI as it has the potential of reducing the overhead in downlink control channel.
- We support FR2 SCell scheduling for PUSCH on FR1 as it can reduce the load on the downlink control channel on FR1 cell.
- Regarding cross carrier HARQ, we don't see a strong motivation to support such feature.

10 – Nokia Corporation

We do not see cross carrier operation enhancements important in Rel-18.

11 – ZTE Corporation

Of the three features, multi-cell scheduling with single DCI is of highest priority from our perspective.

For multi-cell scheduling with single DCI, based on preliminary Rel-17 previous simulation results, the gain may increase as the number of the scheduled cells increases. Thus, we support this enhancement in Rel-18. Meanwhile, a study phase for it may be needed for companies to perform simulation and investigate whether the gain is attractive. Also, we may need to take multi-slot PDSCH/PUSCH scheduling into account as the baseline since both of them have been specified in NR.

Regarding FR2 SCell scheduling for PUSCH on FR1 PCell, this can be considered as an extension of Rel-17 SCell scheduling PCell. However, the motivation of this enhancement is not so strong compared with others.

Regarding cross carrier HARQ, we see some benefits of supporting it, e.g., reducing the transmission delay. However, if any enhancement is agreed we should ensure that RAN2 impact is minimised as highlighted by other companies.

12 – Apple Hungary Kft.

Regarding "multi-cell scheduling with single DCI", we do not support this enhancement. If there is any benefit, this enhancement is mainly to reduce the total DCI size. Except a limited number of DCI field and CRC, the DCI size cannot be reduced without impacting the scheduling flexibility. We already introduced DCI Format 0*2 and 1*2 to reduce DCI size. Furthermore, the combined DCI will almost inevitably have larger size which will impact the DCI reliability. In the end, given the supreme performance that 5G is marketing at and promising with, we do not think saving limited amount of DCI size is something that can benefit NR. In fact, the real issue with cross carrier scheduling now, especially in terms of deployment, is the lack of limitation on the number of scheduled cells that can be scheduled by a single scheduling cell (right now, it is up to 8). If there is any enhancement, limiting the number of scheduled cells that can be scheduled by a single scheduling cell is the first priority.

Regarding "FR2 SCell scheduling for PUSCH on FR1 PCell − cross carrier HARQ", we need clarification about the scope of this item. In general, we are not supportive. There are two possible areas discussed in the past

- Cross carrier HARQ retransmission of the same HARQ process, similar as PUCCH carrier switching that will be specified in Rel-17. We do not think it should be a high priority
- Allowing sSCell in FR2 to schedule FR1 for DSS enhancement. We do not think it is needed. FR2 cannot provide as reliable communication as FR1 and it requires more power consumption with more thermal dissipation. We do not see a reason for UE to support FR2 sSCell to schedule SpCell simply for DSS. Therefore, there is no incentive to specify it in Rel-18

13 – Futurewei Technologies

On these 3 items:

Multi-cell scheduling with single DCI: we support this feature in Release 18 based on the studies performed in Release 17.

FR2 SCell scheduling for PUSCH on FR1 PCell: we fail to see a good use case and benefit of this feature and suggest to be low priority for Release 18 consideration

Cross carrier HARQ: this feature was proposed before and we think it can potentially benefit the URLLC use case under the CA scenarios by providing additional diversity in carrier domain to improve reliability and latency. For URLLC, till Release 17, time domain (via repetition and re-transmission though limited for low latency) and spatial domain (via multi-TRP) diversity has been employed but not the carrier domain. Therefore, we think this feature needs to be supported in Release 18.

14 – Orange

we are supportive of multi-cell scheduling with a single DCI as this would bring some capacity gains, mostly for inter-band in FR1 case

FR2 SCell scheduling for PUSCH on FR1 Pcell is not needed to our mind

we don't have a strong opinion on cross carrier HARQ

15 – MediaTek Inc.

- Multi-cell scheduling with single DCI: We support this enhancement and think this is very important for UE support of CA with larger carrier number. It is also **beneficial for network by realizing full scheduling flexibility with less requirement/dependency on UE blind decoding capability**.

- FR2 SCell scheduling for PUSCH on FR1 PCell: **We think this can be an application of multi-cell scheduling with single DCI and prefer if the two items can be merged in an unified solution**. In R17, UE blind decoding complexity is the main consideration for SCell scheduling PCell, and such concern can be eliminated with single DCI scheduling which keep UE blind decoding complexity the same as one carrier case.
- Cross carrier HARQ: We see operating latency critical services, e.g., AR/VR, in CA with TDD motivates the demand. **With R16 unaligned CA, TDD patterns of inter-band carriers can be made complementary. In R17, there developed cross-carrier switch for HARQ ACK/NACK, and the latency reduction benefit can be maximized with cross-carrier switch for HARQ retransmissions.**

  Impact to MAC layer can be minimized if retransmission still follows the HARQ setting of its 1st transmission carrier and UE routes data to/from the corresponding HARQ buffer/memory. Specifically, R18 can consider cross-carrier HARQ enhancement subject to minimum impact to MAC layer HARQ management.

  Finally, we would like to highlight the equivalency between cross-carrier operation enhancement and flexible spectrum integration. Both are to **make multiple carriers operated as efficiency as a single carrier where the flexible scheduling of data/retransmission across different PRBs can be realized with a single DCI. Such demand can effectively be fulfilled by enhanced CA with cross-carrier HARQ and multi-cell scheduling with a single DCI**.

16 – VODAFONE Group Plc

We support R18 work on:

multi-cell scheduling with single DCI

FR2 SCell scheduling for PUSCH on FR1 PCell

17 – Verizon UK Ltd

We support

- Multi-Cell scheduling with a single DCI
- FR2 SCell scheduling for PUSCH on FR1 PCell - may not be useful for all cases but there are definely scenarios that this is useful. FR1 resource could be very limited in some cases and FR2 could be reliable there as well,

18 – Intel Corporation (UK) Ltd

DSS allows LTE and NR to share the same carrier by dynamically allocating resources to LTE or NR users depending on the traffic loading conditions. At the same time, since commercialization of Rel-18 NR features is not expected earlier than by 2024, the relative ratio of LTE users comparing to NR user by that time are expected to be substantially reduced. As the result DSS enhancements in Rel-18 should primarily focus on the scenario, where the number of NR users noticeably exceeds that the number of LTE users. As a result, the PDCCH transmission on PCell/PSCell becomes an even larger limitation factor. It is beneficial to further enhance cross-carrier scheduling. The first two bullets were discussed in R17 DSS. And these two items can be considered as the extension of R17 DSS. We may consider these two enhancements based on R17 DSS, and these two should be led by RAN1.

- o FR2 Scell scheduling for PUSCH on FR1 Pcell (RAN1)
- o Multi-cell scheduling by single DCI (RAN1)

19 – SK Telecom

We support R18 work on:

multi-cell scheduling with single DCI

FR2 SCell scheduling for PUSCH on FR1 PCell

Moderator's conclusion:

- Regarding "multi-cell scheduling with single DCI":

Considering the wide support, the moderator thinks that in principle this could be added as a WI objective, for both intra-band and inter-band, FR1 and FR2. However the relationship with the discussion on flexible spectrum integration needs to be checked first. See a possible proposal for this in Section 3.

- Regarding "FR2 SCell scheduling for PUSCH on FR1 PCell":

There is some support but also some concerns on the use cases for this (e.g. considering the possible different coverage in FR1 and FR2). However, if multi-cell scheduling with single DCI will support inter-band scenarios, it seems that this can be considered as part of the multi-cell scheduling with single DCI solution. See a possible proposal for this in Section 3.

- Regarding "cross carrier HARQ":

There is some support but also substantial objection to this, both in terms of justification and especially due to the expected complexity/standardization effort. Moderator's suggestion is not to consider this for Rel-18. However the moderator believes that if a "single serving cell" framework will be introduced in Rel-18, this aspect might have to be reconsidered.

2.2 MR-MC with more than two active cell groups

Regarding MR-MC with more than two active cell groups, companies are invited to provide their view:

- on the justification,
- on how this would work (e.g. how many cell groups are expected to be active in DL and UL),
- on whether this is intended for all multi-RAT options or only for some of them (e.g. only for "NR-MC"),
- on the expected impact on the different WGs

Feedback Form 2:

1 – China Telecom Corporation Ltd.

Justification

Regarding MR-MC, we think it is a straightforward and beneficial way to provide higher bandwidth and capacity and also guarantee user experience. Firstly, due to the high 5G frequency bands up to 100GHz and with the gradual 4G frequency refarming, more 5G frequency bands will be unlocked. Multi-layer overlapping deployment will be a normal behaviour for future network. As network operator, we also see potential commercial requirements and deployment scenarios to extend MR-DC to MR-MC in 5G-A. Multi SNs can help increase bandwidth and capacity significantly in hotspot and overlapping areas.

Moreover, as we all know, CA is a typical way to provide high rate and large capacity, but requires co-located and overlaid or higher backhaul quality. In the actual network deployment, 5G gNBs are constructed phase by phase. Considering the 4G frequency refarming in the future, the former deployed eNBs/gNBs might not be able to co-locate with the gNBs deployed later. If it is hard to deploy ideal backhaul, CA might not solve the capacity issue. Considering the Multi-layer overlapping deployment scenario and higher bandwidth and capacity requirements for new services in the future, MR-MC will be a meaningful enhancement for Rel-18.

How this would work (e.g. how many cell groups are expected to be active in DL and UL)

Regarding the details of MR-MC, we think the following potential objectives or issues are worth discussing in Rel-18.

(1) The number of simultaneous UL transmissions and DL receptions in Rel-18:

In order to balance the UE implementation complexity/RF capability limitation and network performance, we suggest support at most 2 simultaneous UL transmissions and potential extension to 3 DL receptions in Rel-18.

(2) Mechanisms and signalling for multi cell groups management, including

- Fast and dynamic SCG activation and deactivation, such as extending Rel-17 efficient SCG activation / deactivation mechanism to multi SCGs, further discussion on Rel-17 leftovers including UE autonomous SCG deactivation, etc..

- UL selective activation mechanism, such as dynamic UL switching or forwarding between SCGs to make the UE work in a “TDM manner” in the Uplink.

Whether this is intended for all multi-RAT options or only for some of them (e.g. only for ”NR-MC”)

From the actual network deployment aspects, we think multi-RAT options are possible. E.g. MN(1.8GHz LTE)+SN1(3.5GHz NR)+SN2(NR FR2). Considering the future network deployment, we think NR-MC might be a more general case, which can have a higher priority.

The expected impact on the different WGs

We understand the main work about MR-MC is related to RAN2 and RAN3, such as mechanisms and signalling for multi cell groups management. There might have some impact on RAN1, such as UL power control or UL switching time coordination. Therefore, we suggest RAN2 would be the leading WG, and RAN3/RAN1 can be secondary WGs.

2 – Ericsson LM

The justification for MR-MC is unclear. The deployment scenario would assume that the operator has a macro frequency layer, and at least two pico frequency layers. The best capacity and throughput is

achieved if all frequencies are used in all nodes. So, while the deployment scenario of having three different frequency layers which are used by three different types of nodes may exist, it is not the most common nor efficient scenario. And in particular it would not be worth specifying a solution which optimizes this scenario.

The impact of this would be huge as in the RAN specifications it is deeply rooted that Dual Connectivity has two cell groups, not three or more. The UE would also need multiple uplinks which we believe is not common. And the gain of this is questionable, also since the UE will need to split the uplink power between these uplinks, and managing this split (semi)-statically or dynamically is complex and inefficient. One can of course assume that three is 50% more than two. But of course it is not that simple, e.g. coming back to the deployment scenario it is more beneficial to have all frequencies in all nodes.

Dual Connectivity (i.e. two legs) is already complex enough.

3 – HuaWei Technologies Co.

For MR-MC, we understand the scenarios to configure multiple CGs with 2 active ones are under discussion in mobility already, and the discussion here is for more than 2 active CGs only.

We are not convinced on the urgency of commercial needs to support more than 2 active CGs. If the case is mainly to address NR low frequency and high frequency combinations, CA has better performance and is simpler than DC case. In case there is non-ideal backhaul deployment, with two activated CGs seems already sufficient considering the UE capability up to 2Tx is typical in the existing marketing. In Rel-17 it is already possible to configure multiple candidate SNs and let UE select one of them to access, thus it is a bit unclear what else is missing.

4 – Samsung R&D Institute UK

Justification: More and more 5G frequency bands are already available or will be available soon for many operators. Even in the same frequency range, multiple frequency bands can be available, e.g. [FR1:800 MHz] + [FR1:3.5 GHz] and [FR2: 28 GHz] + [FR2: >52 GHz]. Then, it is natural to pursue to support aggregation of all those available bandwidths to provide services efficiently and effectively. Existing DC cannot easily support the aggregation of FR1 (low band) + FR1 (high band) + FR2 or LTE + FR1 + FR2. Since DC can configure at most two RAN nodes, part of frequency bands has to be combined by inter-band carrier aggregation (CA). However, CA has a limitation of network deployment requiring co-located DUs or ideal backhaul. Considering coverage asymmetry among different frequency bands, this is a strong restriction which needs to be loosened in the near future. Otherwise, at the deployment of multi-band aggregation, not only increasing cost from operator side but also implementation/deployment difficulty from vendor side are expected due to the ideal interface for CA. In this context, Multi-RAT Multi-Connectivity (MR-MC) is an easiest way to provide further throughput enhancements and more flexible deployment scenarios.

Active 3 DL CGs and 2 UL CGs: There may be a concern from UE side. UE is power-limited and has hardware limitation. That is the reason why at most two uplink cells for a single UE are currently supported so far. The extension to MR-MC also needs to consider this, so the standardization of MR-MC should keep the assumption of at most two uplink transmissions at a given time. For instance, selective UL activation can be considered. It is true that MR-MC with 3DL + 2UL does not have much difference from DC with 3DL + 2UL from RF perspective. The restriction of at most two active ULs does not increase UE-side complexity whereas DL throughputs can be increased by the number of aggregated cell groups. We consider to support multi-RAT options but we are also fine to start with NR-MC options.

Main Impact to WGs:

- RAN1: Active cell group switching
- RAN2/3: Bearer type extension to three CGs, signaling support.

5 – LG Electronics Inc.

The impact of supporting more than two active cell groups would be high which would include tight coordination between the cell groups regarding resource distribution/negotiation/scheduling and RAN1/2/3/4 may all need to be involved to see if more than two active cell groups can work practically. We see no urgent reason to support more than two active cell groups in Rel-18.

6 – Spreadtrum Communications

For the MR-DC with more than two active cell groups, we see the scenarios and benefit for the deployment with FR1+FR2 multi-layer. To achieve more capacity and enhance user experience, it can be considered for further enhancement in Rel-18.

7 – LG Uplus

For the justification, we see the benefit when we use FR1(NR or LTE low band) + FR1(NR mid band) + FR1/2(NR mid or high band).

Regarding how many cell groups are expected to be active in DL and UL, as many companies indicated, 3DL/2UL would be the maximum for this Release-18.

Regarding whether this is intended for all multi-RAT options or only for some of them (e.g. only for ”NR-MC”), as I mentioned in justification part not only NR-MC, but also EN-MC could be useful as from my understanding, EN-DC is the most popular configuration.

For the expected impact on the different WGs, it seems RAN1/2/3/4 should be involved.

8 – NTT DOCOMO INC.

Support of more than two active cell groups achieves flexibility for the design of accommodating cells in gNBs. Also note the impact that more inter-gNB coordination may be needed. We should carefully evaluate both benefits and spec impacts.

9 – Beijing Xiaomi Mobile Software

We have some concerns on the impact on the specifications if we extend MR-DC to MR-MC(3 activated DL + 2 activated UL□.

Since at most 2Tx chain is transmitting at the same time from UE perspective, we need to specify selective activation limiting the number of uplink active CGs to two. And we also need to forwarding HARQ or RLC feedback via Xn if the uplink and downlink link is not linked to the same node. Another issue is we need to further identify the additional gains when having three legs than 2 legs.

10 – NEC Corporation

First of all, we understand this would mean to support/configure two or more SCGs. For this scenario, there is big difference depending on whether the UE needs “triple” Tx/Rx (at least for two SCGs) or not? To obtain the actual benefit, the UE should be able to perform Tx/Rx simultaneously in more than two SCGs in addition to MCG. There might be some benefits in a hierarchical cell deployment involving more than two SNs. For example, SCG frequencies are divided into e.g. two frequency groups, where each of frequency group are managed by different (group of) SNs. We need operators’ view if such cell deployments are expected.

Regarding "how many CG?", at least in the first phase of this MR-MC, the number of active SCGs should be at most two. Having more active SCGs just makes specification unnecessarily complicated.

Regarding "architecture options", this must not involve E-UTRA as SCG. Probably NR-DC would be sufficient in reality and for simplicity.

Regarding "impact on different WGs", this will impact on RAN1, 3 and 4. All RAN WGs should be involved.

11 – China Mobile Com. Corporation

Regarding MR-MC, we think it has significant impacts on UE complexity and we don't see urgent and definite commercial needs. We suggest the study on MR-MC can be postponed in this release.

12 – InterDigital Communications

We support more than two active cell groups as it provides additional bandwidth. NR-DC can be used as a baseline to support multiple active cell groups. Regarding the number of active cell groups it can be left to the working groups for further discussion.

For Rel-18 we think NR-MC should be the main case and multi-RAT options can be left for future releases. We expect impact on RAN1/2/3/4

13 – Nokia Corporation

Practical need and justification are not clear to us. Also the benefits of such complex solutions are not clear and we expect that the Rel-17 enhancements for SCG change (e.g. CPA, CPC, SCG deactivation) can likely already provide majority of potential benefits of this procedure. As this topic also seems to require substantial time from all WGs involved, it shouldn't be started without studying the use cases and benefits achievable compared to existing solutions. Many companies don't even mention RAN4 work being required for this although we know from the past that even DC requirements have taken multiple releases to complete, and it's possible this topic could require efforts from both the RF and RRM tracks.

14 – ZTE Corporation

MR-MC may be useful in general, however, we think having more than 2 active CGs is complex from UE implementation perspective and would be prohibitively expensive from implementation perspective. Hence, we think any enhancement in Rel-18 should focus on maximum of 2 active CGs (as being discussed as part of the mobility enhancements thread for instance). Any thing more than 2 CGs can be discussed in later releases if there is enough support.

15 – QUALCOMM JAPAN LLC.

We think that the feature is highly complex, while the gain over the solution configuring more than 2 CGs while only two CGs are active (discussed in mobility email discussion) is unclear.

Realistically we should assume the UE can have only two active cell groups in terms of UL. Then having more than two active cell groups for DL requires inter-node coordination for scheduling, e.g. HARQ feedback on one cell group for DL reception on another cell group, or TDM DL scheduling to allow switched UL for feedback. This itself requires a feasibility study (similar proposal for release-18; "inter-gNB CA").

Also necessary inter-node coordination for radio resource configuration while sharing the UE capability among more than two network node is going to be very complex and difficult to implement in practice.

16 – Apple Hungary Kft.

17 – Futurewei Technologies

The use case that needs to supporting more than 2 active cell groups for multiple radios (NR and LTE) is very rare and benefit not clear comparing other solutions. As companies have pointed out, it is also very complicated, especially for devices. Therefore, we think it should not be included for Release 18.

18 – MediaTek Inc.

We cannot support this enhancement for the following reasons:

- gNB utilization of multiple frequency ranges/bands doesn't mean UE needs to simultaneously receive all the frequency ranges/bands. gNB can properly assign two cell groups for each UE (as per user application requirement) while distributing UEs across all spectrum bands to maximize the overall system capacity. It is sufficient to require UE support two active cell groups across three or four frequency bands.
- If tight timing alignment among component carriers of CA is the major concern, there is enhancement in RAN4 to enable CA operations under relaxed timing alignment. We see this direction is more feasible and practical approach for network to utilize more frequency bands and leverage well-supported CA framework.

19 – Intel Corporation (UK) Ltd

For mobility scenario, we understand that multiple cell groups can help the UE to maintain the throughput during mobility upon change of cell groups. If we do not consider mobility scenario, based on previous discussion, seems the only gain for this more than two active cell groups is to increase the throughput. It may come free if the solution specified for mobility can be reused . However throughput is related to the total aggregated bandwidth and not the number of cell groups that the component carriers are arranged into. In addition, having more than 2 UL CCs supporting PUCCH would rather reduce UL coverage/throughput. We would like to understand what deployment scenario would want to arrange the carriers as 3 CGs rather than 2 CGs. I

Moderator's conclusion:

Regarding "MR-MC with more than two active cell groups", there is some support but also wide objection to this, both in terms of justification and especially due to the expected complexity (in the UE and in the network)/standardization effort. Impacts are expected in RAN1 (for simultaneous reception on more than 2 DL and for selective activation of 2 out of 3 UL), in RAN2 (to move from a MR-DC to a MR-MC signalling framework), on RAN3 (for inter-node coordination among 3 nodes) and on RAN4 (for multi-band combinations, etc.). The suggestion is not to consider this for Rel-18.

2.3 Flexible spectrum integration

Regarding the proposal for "flexible spectrum integration", considering that quite different aspects were mentioned in the previous rounds of discussion, companies are first of all invited to comment separately on the specific aspects discussed so far, including justification why they are considered as needed/not needed and the expected impact on the different WGs.

- Decoupling of uplink and downlink bands for UEs in CONNECTED, INACTIVE, IDLE mode for various cellular operations (initial/random access, paging, PDSCH/PUSCH transmission, etc)

Feedback Form 3:

1 – China Telecom Corporation Ltd.

We would like to propose a SI for the topic of flexible spectrum integration, as companies had diverse views to the benefits for some of enhancements over CA framework, in which a considerable amount of companies were claiming "obvious benefits".

According to the endorsed summary from RAN chair in RP-212608, the flexible spectrum integration shall base on the CA framework. Thus, we propose to study the objectives as listed below.

1) Overhead reduction

-Simplifying SSB, SIB etc. resources to be allocated in Pcell.

-Focus on the FR1 fragmented bandwidths in which the bands are neighboring, e.g. 700MHz/800MHz/900MHz, 1.8GHz/2.1GHz, 1.9GHz/2GHz/2.3GHz etc. Study on how narrow bandwidth per carrier is will show benefit (e.g. CBW<=50MHz per carrier)

-Study on load balance issue and if needed identify potential solutions for SSB/SIB-less proposal. (e.g. transmit PRACH/Msg3 in Scell)

2) Cell management: Study on the feasibility and benefit to enable flexible association of downlink and uplink carrier for one cell in one or multiple frequency bands for FR1

-The initial access and UL heavy traffic are identified as potential scenarios for flexible DL/UL association to achieve benefit.

3) RF impact (RAN4)

- As a starting point, the requirements for associated downlink and uplink carriers could follow corresponding band combination without specifying any additional requirements

2 – Ericsson LM

Decoupling of UL and DL would be very attractive from flexibility point of view to adapt for different traffic scenarios. For example, one can gain UL coverage for both Mid-band and High-band. However, the real system gain is not clear and what is proposed can be achieved already within today's CA framework with certain enhancements. There are several heavy issues embedded:

- This will create high complexity in radio regulation since the traditional FDD band is fixed with spectrum allocation
- This will create huge band combination-workload for RAN4 due to the need to solve intermodulation issues, etc.
- System gain will be limited due to beamforming functionality still needing its own UL for signalling and having UL and DL too far away from each other in frequency will result in loss of channel reciprocity
- Some proposals for this would cause very high complexity and hence are unlikely to ever be implemented, especially for the high band scenarios.
- Backwards compatibility for the network that has already been rolled out

3 – China Mobile Com. Corporation

To realize flexible offloading from initial access and improve spectrum utilization efficiency of multiple wide or narrow band carriers, enhancement of multi-carrier operation is needed to realized flexible spectrum integration. One proposed way is that different frequency carriers, regardless of intra-band, or inter-band, can be configured in a single cell.

By this way, multi-carrier operation is extended to initial access phase, where carrier selection for initial access in a cell is no longer limited to the carrier on SUL bands, but also can be the carriers on existing TD-D/FDD bands. For connected mode, the SUL carriers can also be aggregated to improve uplink throughput for high SINR UEs, this is useful for UL heavy traffic.

With this single cell architecture, more flexibility is allowed to couple the uplink and downlink. For example, if the UE has chosen one FDD UL band for initial access, of course it can use the corresponding downlink FDD band for reception if gNB has configured related search space for downlink monitoring. While if related search space during initial access is only configured on some of the carriers, the downlink reception carrier and uplink transmission carrier may be different during initial access.

For UEs with single carrier capability, it may be better for them to work on defined FDD or TDD bands. While for UE with multi-carrier capability, its downlink and uplink can be coupled flexibly, for example, UL heavy traffic may require more UL carriers than DL carriers for some UEs.

So with this enhanced single cell flexible spectrum integration scheme, the feasibility and benefit of decoupling of uplink and downlink bands for UEs can be studied.

Proposed objective,

- **Study mechanisms for supporting configuring multiple consecutive or non-consecutive spectrums in one single cell, e.g., from perspectives of common system information, cell (re)selection, and inter-cell management, etc. □RAN2□**

- **Study the feasibility and benefit of decoupling of uplink and downlink bands for UEs in CONNECTED, INACTIVE, IDLE mode for various cellular operations (initial/random access, paging, PDSCH/PUSCH transmission, etc) (RAN2, RAN1, RAN4)**

4 – HuaWei Technologies Co.

We support this work in general. As we explained before, there are bands distributed non-contiguously in the spectrum, especially for sub-3G FDD bands. If there is efficient way to aggregate these bands together, it can provide similar DL bandwidth and more UL bandwidth than a C-band TDD carrier with coverage advantages. This is seen commercially valuable.

For this decoupling aspect, for UEs in idle and inactive mode, we see the use cases that the UE may select different UL for initial/random access while the DL band is not changed. This gives the flexibility to the operators on balancing the initial access from the users among different carriers. By the same reason, paging can also be sent on one DL band, and the paging response can be sent on another UL band using random access. To achieve so, we understand the system information needs to be extended to support multiple UL bands for one DL band.

For UEs in connected mode, we think the major impacts are addressed in the following two questions. We provided more detailed analysis under those two questions.

In summary we support the following enhancements for idle and inactive modes as below:

- **extend system information to allow configuration of resources on multiple UL bands [RAN2]**

- **enhancements of initial access procedure to select the UL among multiple UL bands [RAN2, RAN1]**

Regarding Ericsson's question, we understand for idle and inactive mode, it is as usual that the UE read the system information and then if it supports it camps on, otherwise the UE can try to camp on another cell. For connected mode the configuration from the network should be based on UE capability reporting. There seems no backward compatibility issues. It is also unclear about the inter-modulation issue, this is a generic issue for certain band combinations and is not specific to this discussion.

5 – SoftBank Corp.

Multicarrier operation is a baseline in the commercial network. On the other hand, the basic CA framework is almost same from LTE era, then we can only see a very slow progress on the CA enhancements. It would be interesting to know if Flexible spectrum integration techniques can be a breakthrough. We are positive to have a study of Decoupling of uplink and downlink bands and other aspects below.

6 – Samsung R&D Institute UK

First, we would like to clarify what would be additional points over the current CA/DC framework. E.g., what is NOT possible with CA/DC framework? (which was already raised in previous email discussions)

Decouple of uplink and downlink bands would have an implication on regulatory and RAN4 RF aspects. In addition, beyond current CA/DC framework, we are lacking of the understanding of implementation impact (UE/BS) from the proposal.

7 – LG Electronics Inc.

1) Decoupling of uplink and downlink bands for UEs in CONNECTED, INACTIVE, IDLE mode for various cellular operations (initial/random access, paging, PDSCH/PUSCH transmission, etc)

We have similar view with Samsung.

The different points pursued by having it from the existing CA framework and the aspect currently unable to be addressed by the existing CA framework, are to be clarified first.

2) Improved BWP switching and activation/deactivation procedure for non-contiguous frequency resources in different bands

We have similar view with Ericsson and Samsung.

The scenario where non-contiguous carriers are to be co-located is restrictive, and we already have fast Scell activation mechanism introduced in Rel-17 DSS WI.

3) Overhead reduction including PDCCH in one band scheduling multiple bands, SSB/SIB in one band providing synchronization and system information for multiple bands

We have similar view with Ericsson.

To bundle multiple bands as a single cell where a specific band operates as anchor would require large impacts to RAN4 aspects/measurements and restrictive (e.g. co-located) requirements.

8 – Spreadtrum Communications

We can support the proposal of decoupling of uplink and downlink bands. But first we should study this topic to get a clear benefits of it. Also it will affect the initial access procedure, including impact on system information, cell selection/reselection, paging and so on.

9 – Nokia Corporation

In our view CA frame work is sufficient and we do not see need or justification for this type of additional new solutions and studies.

10 – ZTE Corporation

We are open to decoupling of uplink and downlink bands considering that it can offer more flexibility to the system. Enhancements should reuse the existing framework as much as possible and hence should have minor spec/implementation impacts.

Meanwhile, backward compatibility issue should also be taken into account. Cells decoupling uplink and downlink bands should allow legacy UEs to access into them.

At this stage, it would be better if companies can make the potential objectives clear instead of just saying "decoupling of uplink and downlink bands". Otherwise, it is not possible to evaluate the TU for it.

11 – CATT

We support decoupling of uplink and downlink bands for UEs in CONNECTED, INACTIVE, IDLE mode for improved utilization of non-contiguous frequency resources in different bands. It allows random access in different uplink bands associated with the same downlink band which may bring the benefits of coverage improvement, collision reduction, load balancing etc.

12 – QUALCOMM JAPAN LLC.

It is still not clear to us how fragmented the spectrum allocation can be (e.g. how narrow the bands could be?), and if it justifies the introduction of a new framework on top of the existing CA framework.

13 – Apple Hungary Kft.

14 – China Unicom

For non-contiguously band in lower frequency, bands aggregation may bring tremendous benefits for both uplink and downlink if more UL carriers combined with some DL carriers.

Considering the benefits of the decoupling of uplink and downlink bands, it will bring in the flexibility of network resource utilization, e.g. the UE distribution in different carriers, related with

initial/random access, and paging procedures, and system information enhancement.

Potential objectives:

- **Support system information enhancement to configure resources on multiple UL carriers.**
- **Support the potential enhancements on initial access/random access, paging as well as some other procedures if identified the potential impact.**

15 – Futurewei Technologies

The motivation of flexible spectrum integration include overhead reduction, more flexible and faster cell/resource management, DL and UL carrier decoupling, potential power savings at the network and the devices, etc. Enhancing and expanding the current CA framework can potentially achieve these benefits to some extend while introducing a new framework can do better but with the cost of more standards impacts. implementation complexity, and potentially longer market penetration time. However, for 5G advanced such new framework is worth exploiting if it indeed provides significant advantages. Considering the tradeoffs and the views from companies, a study is warranted to investigate use cases, design targets, and frameworks. Our suggestion is to have study item followed by a work item based on the study outcome.

16 – Orange

we tend to agree with Ericsson that UL / DL decoupling is quite complex. While we see it as useful in the context of SDL + SUL, we are less convinced for a more generalized usage of UL / DL decoupling

17 – MediaTek Inc.

We see cross-carrier operation enhancements can already realize the benefits of flexible spectrum integration:

- Flexible PDSCH/PUSCH scheduling: Flexible scheduling of data/retransmission across different frequency bands with a single DCI can be achieved by enhanced CA operation with cross-carrier HARQ and multi-cell scheduling with a single DCI.

- Initial/random access and paging: These are all single-carrier operations, and we are not very clear why they are related to flexible spectrum integration.

Overall, it looks using CA with a lower-frequency-band carrier as PCell (for effective initial/random access and paging) and higher-frequency-band carriers as SCell (PDSCH/PUSCH offloading) can already realize the target benefit of flexible spectrum integration.

18 – VODAFONE Group Plc

We support further study in this area

19 – Verizon UK Ltd

Support further study. We are not quite clear how is this related to CA/DC framework as well but tools of this nature are very important to us as an operator. If there is a chance to have something providing the claimed benefit, we think it is worth a study on it at least.

20 – Intel Corporation (UK) Ltd

The NR CA already support a flexible management of DL and UL cells, especially considering that multi-cell scheduling by single DCI can be supported. Therefore, we would like to understand what additional gain it can achieve compared with CA framework. In addition, it would good to clarify how this proposal is related to the UL Tx switching proposal under email thread RAN94e-R18Prep-02, which seem to address a similar use case for the UL CA, when the number of Tx chains is less than the number of activated carriers and UE needs to switch its Tx chain across different UL carriers. We should avoid the duplication discussion and overlapping scope across different items.

21 – TELUS

We share the opinion of several operators who expressed an interest in at exploring this during the study item phase and to determine if there is real benefit. Spectrum fragmentation is a real issue, and CA may need to evolve to avoid the problem of having subsets of possible permutations only available.

Moderator's conclusion:

Regarding "Decoupling of uplink and downlink bands for UEs in CONNECTED, INACTIVE, IDLE mode for various cellular operations (initial/random access, paging, PDSCH/PUSCH transmission, etc)" there is some support but also some objection to this, mainly for the implications on regulatory / RAN4 RF aspects and possible major changes to the existing framework.

It is uncertain whether it can be more acceptable to companies if this is limited to certain scope, e.g. CONNECTED mode based on the existing framework. See a possible proposal for this in Section 3.

– Improved BWP switching and activation/deactivation procedure for non-contiguous frequency resources in different bands

Feedback Form 4:

1 – Ericsson LM

It is true that when there is no Pcell and Scell, the BWP switching and activation/deactivation can be improved. However, this can be achieved within CA enhancement. Certain issues should be noted:

- If Pcell and Scells should be regarded as one cell, this first will require same HARQ procedure which will require in the low band which traditional FDD band becoming TDD configuration.
- As one cell also require non-contiguous frequency carriers to be co-located which is more restrictive than normal carrier aggregation.

2 – China Mobile Com. Corporation

With single cell flexible spectrum integration scheme, enhancement of connected mode can be considered, legacy CA behaviour or BWP framework can be reused. Flexible multiple carriers operation can be realized by BWP like fast switching between adjacent frequency resources due to their similar channel propagation characteristics. The carriers can be fast activated/deactivated for such case, the network and UE power consumption can be reduced.

While for inter bands with different channel propagation characteristics, since they belong to the same cell, L1 based carrier switching can replace handover procedure, the carrier switching delay can also be reduced.

So for this aspects, we propose the following objective,

- **Study and if agreed to specify the enhancement to support more flexible and faster carrier scheduling and aggregation in connected mode for non-contiguous frequency resources in different bands, e.g. BWP-like carrier switching and activation/deactivation procedure.(RAN1,RAN2, RAN4)**

3 – HuaWei Technologies Co.

Yes we support this in principle.

Our consideration is that by base station implementation, the DL time/frequency may be well synchronized for the non-contiguous frequency resource in different bands. This allows UE to utilize the DL time/frequency synchronization from one band for another band. Consequently, the UE may not need to perform the time/frequency synchronization and thus can reuse BWP mechanism to (de-)activate the carriers/bands or reduce the Scell activation/deactivation time.

In previous discussion, the main controversial part is whether it uses single serving cell framework or CA framework. We thus provide our analysis below based on each framework.

For single serving cell framework, the existing BWP switching mechanism can only be done within one carrier and cannot support the inter-band case. If the UE can get the DL time/frequency synchronization for another band, the BWP switching can be applied to inter-band case as well. In addition, according to the UE capability, multiple active BWPs can be configured and activated/switched without first searching/activating SCells as needed in the CA framework, which can further reduce the latency of carriers/bands (de-)activation to the level of existing BWP switching.

For CA framework, the latency of SCell activation is already improved in Rel-17 by introducing temporary RS, but the existing CA mechanism still assumes that each carrier is deployed independently and thus synchronization and RSRP acquired for AGC setting are needed for each cell, sometimes cell search is also needed. If the UE can get the DL time/frequency synchronization for another band, the activation procedures can be further improved, e.g. at least temporary RS is no longer needed.

In summary we support the following enhancements:

- **In case of single serving cell framework [RAN2, RAN1]**
  - **improvement of BWP switching and (de)activation procedures to reduce the activation latency**
  - **support of multiple active BWPs (e.g. one active BWP per band/carrier)**
- **In case of CA framework [RAN1, RAN2]**
  - **Improvement of Scell Activation procedures to reduce the latency, e.g. at least the temporary RS is no longer needed**

4 – Samsung R&D Institute UK

In CA/DC framework, SCell activation/deactivation procedure has been enhanced for Rel-16 & 17 which enables UE power saving and fast cell switching (activation).

5 – LG Electronics Inc.

We have similar view with Ericsson and Samsung.

The scenario where non-contiguous carriers are to be co-located is restrictive, and we already have fast Scell activation mechanism introduced in Rel-17 DSS WI.

6 – Nokia Corporation

In our view CA frame work is sufficient and we do not see need or justification for this type of additional new solutions and studies.

7 – ZTE Corporation

We are not convinced that this enhancement is needed. The current BWP switching works well and is agnostic to the frequency bands. If the intention of this is to introduce multi-band serving cell, as we discussed previously, introducing a totally new framework at this stage requires quite a lot of spec changes and implementation complexity, which should be avoided as much as possible.

8 – CATT

We support improved BWP switching and activation/deactivation procedure for non-contiguous frequency resources in different bands. BWP switching can be reused for single serving cell framework. For CA framework, we agree with Huawei that further improvement should be considered compared to existing SCell activation procedure in Rel-17 considering that the DL time/frequency synchronization can be got from another band.

9 – QUALCOMM JAPAN LLC.

We share the same view with Ericsson and Samsung.

10 – Apple Hungary Kft.

11 – Futurewei Technologies

Please see our response to Question 3

12 – MediaTek Inc.

If the main intention is to realize shorter activate/deactivation latency than CA, we are wondering if R16 SCell dormancy can already serve the purpose? We can reuse CA and SCell dormancy (which is also based on BWP operation) to provide very short latency for the access of a frequency band.

13 – Intel Corporation (UK) Ltd

If the non-contiguous frequency resource in different bands are defined as different CCs (i.e. serving Cells), the SCell activation/deactivation and SCell dormancy switching can be used to changes the active SCells. We would like to understand what additional gain it can achieve compared with CA framework.

14 – China Unicom

We support this bullet. If DL time/frequency is synchronized for the non-contiguous frequency resource in different carriers, then UEs can share the time/frequency synchronization in different carriers, which can help to reduce the Scell activation/deactivation time.

In single serving cell scenario, if the UE get the DL time/frequency synchronization for another carrier, UE can perform BWP switching easily. In CA scenario, temporary RS is not needed with enhanced mechanism, while each carrier is deployed independently with separate synchronization and RSRP requirements with legacy mechanism.

Then the following enhancements are proposed:

- In single serving cell scenario, activation/deactivation time can be reduced and multiple active BWPs can be supported by enhanced BWP switching mechanism.
- In CA scenario, the latency of Scell activation procedures can be further reduced by removing the signal such as temporary RS, etc.

Moderator's conclusion:

Regarding "Improved BWP switching and activation/deactivation procedure for non-contiguous frequency resources in different bands", there is some support but also considerations from many companies that it's not clear why a new framework would be needed for this. See a possible proposal for this in Section 3.

– Overhead reduction including PDCCH in one band scheduling multiple bands, SSB/SIB in one band providing synchronization and system information for multiple bands

Feedback Form 5:

1 – China Telecom Corporation Ltd.

We support to study on the benefit for this objective overhead reduction based on the scenarios as posted in Feedback form 3:

1) Overhead reduction

-Simplifying SSB, SIB etc. resources to be allocated in Pcell.

-Focus on the FR1 fragmented bandwidths in which the bands are neighboring, e.g. 700MHz/800MHz/900MHz, 1.8GHz/2.1GHz, 1.9GHz/2GHz/2.3GHz etc. Study on how narrow bandwidth per carrier is will show benefit (e.g. CBW<=50MHz per carrier)

-Study on load balance issue and if needed identify potential solutions for SSB/SIB-less proposal. (e.g. transmit PRACH/Msg3 in Scell)

2 – Ericsson LM

Clearly overhead reduction will provide certain system gains. However, there certain issues with having only one SSB/SIB in one band, e.g.:

- Regardless of how centralized all the bands are, the traditional RF issues (such as intermodulation issues) still need to be solved.
- Since cells in multiple bands will be considered as one cell, all the carriers needs to be co-located which is a more stringent requirement compared to Carrier Aggregation.
- Also, we have quite a lot of RRM measurements that are SSB based, this will create carrier backwards compatibility issues.
- It is not trivial to select where the SSB/SIB should be broadcasted. To have the SSB in low band may be good for coverage, but would result in poor measurements for the mid band part of the cell.

3 – China Mobile Com. Corporation

To meet the high data rate requirement of NR, wide bandwidth is desired, by aggregating multiple non-continuous carriers with small bandwidth or by using single continuous large bandwidth. It is more practical for FR1 to use the former method to achieve wide bandwidth. For example, there may be some scattered carriers with narrow bandwidth where carry SSB or system information will consume most of the resources. There will also be some carriers re-farmed from LTE, the bandwidth may vary from less than 20MHz to 50MHz or even larger. These carriers with small bandwidth can be continuous or non-continuous, if they are all managed as independent cells, the spectrum utilization efficiency will be low due to large cell management overhead on limited bandwidth, especially for narrow band low-frequency carriers.

With a single cell flexible spectrum integration scheme, multiple carriers share the same cell, common system information and paging can be broadcast only in the anchor carriers, redundant system control information can be avoided for those carriers with narrow bandwidth, and the low frequency bands with limited bandwidth can be fully used for data transmission. Another benefit is flexible offloading. Even when UEs camp on the same DL anchor carriers, they can initiate random access from different non anchor carriers, no need to wait until handover. Therefore, system signaling overhead is reduced and spectrum efficiency is improved.

For coexistence issue raised by former email discussion, when some of the component carriers serve legacy UEs, the overhead reduction benefit may be limited for such component carriers, but still benefit for the other component carriers within one elastic cell. And there are still some NR bands without commercial NR terminals, for example, 4.9GHz band, 6GHz in the future, or bands re-farmed from LTE, the overhead benefit will be significant for such bands.

For connected mode, the control overhead can be further reduced, when multiple carriers are scheduled by single PDCCH.

So we support the overhead reduction objective for flexible spectrum integration scheme and at the same time flexible access should be supported.

The corresponding objective can be,

- **Study and if agreed to specify PDCCH of scheduling PDSCH/PUSCH on multiple carriers using a single DCI. (RAN1, RAN2)**

- **Study and if agreed to specify inter-band flexible access with reduced system overhead: SSB/SIB in one band providing paging and system information for multiple bands.□RAN2, RAN1□**

4 – HuaWei Technologies Co.

Yes we support this in general.

Regarding PDCCH enhancements, the overhead reduction is beneficial for the system. The gains have already been seen in Rel-17 relevant study.

For single serving cell framework, the main enhancements are to support PDCCH in one CORESET scheduling PDSCH (PUSCH) in the multiple BWPs.

For CA framework, the main enhancements are to support single DCI scheduled PDSCH (PUSCH) on multiple DL (UL) cells.

Regarding SSB/SIB, we see values to have SSB/SIB only in one DL band to reduce the overhead. SSB only in one DL band is supported for intra-band case already in Rel-15, but not yet applicable for inter-band

case. Similarly as explained above, the SSB/SIB overhead reduction also requires the UE to be capable of acquiring DL time/frequency synchronization for one band based on another band. The impacts are similar to both frameworks.

In summary we support the enhancements as below:

- **In case of single serving cell framework**
  - **PDCCH in one CORESET can schedule PDSCH (PUSCH) in the multiple BWPs [RAN1]**
  - **Signaling indication for a UE to acquire DL time/frequency synchronization for one band based on another band, for those bands in the one cell [RAN2, RAN1]**
- **In case of CA framework**
  - **Single DCI scheduled PDSCH (PUSCH) on multiple DL (UL) carriers [RAN1]**
  - **Signaling indication for a UE to acquire DL time/frequency synchronization for one band based on another band in the inter-band case [RAN2, RAN1]**

As we explained at the beginning, one scenario beneficial from this enhancement is for sub-3G FDD bands, for example 700/800/900MHz. These bands have similar coverage and there should be no problem for RRM measurment on one DL band. The justification to allow such bands grouped as one serving cell is up to the network, which is configurable and has no backward compatibility issues.

Based on all the above discussion, it can be seen that the major discussion would require more RAN2 work. **Thus we support a RAN2-led item to be approved in December.**

5 – Samsung R&D Institute UK

'PDCCH in one band scheduling multiple bands' overlaps with 'multi-cell scheduling with single DCI' in above section 2.1.

6 – LG Electronics Inc.

We have similar view with Ericsson.

To bundle multiple bands as a single cell where a specific band operates as anchor would require large impacts to RAN4 aspects/measurements and restrictive (e.g. co-located) requirements.

7 – Lenovo (Beijing) Ltd

For overhead reduction using one PDCCH on one band scheduling multiple bands, we think this feature can be realized by multi-cell scheduling via a single DCI. For SSB in one band providing sync information for multiple bands, we see the careful evaluation is required including RAN4 work to ensure the SSB can be accurately applied for other bands. For SIB in one band providing system infor for multiple bands, it could be possible.

8 – Nokia Corporation

We agree with Ericsson comments. In our view CA frame work is sufficient and we do not see need or justification for this type of additional new solutions and studies.

9 – ZTE Corporation

We are open to the enhancements of overhead reduction. Our view for PDCCH in one band scheduling multiple bands has already been included in previous question. Regarding SSB/SIB in one band providing

synchronization and system information for multiple bands, we think this enhancement is useful in practical networks and can reduce the signalling overhead especially for the cells with small bandwidth.

As we mentioned in previous question, a clear set of objectives are very important for this topic, and the objectives proposed by CMCC seems a good way forward.

Considering the limited TU budget, we suggest to focus on only these two objectives in Rel-18 for Flexible spectrum integration, and target a small WI (i.e. 1TU) in Rel-18.

For the two objectives from CMCC, we need to understand if any new framework is needed.

However, considering limited TU, it would be nice to have a quick decision on the framework of the objectives. If no consensus can be made in plenary, we are fine to have a short study phase with the assumption that if there is no convergence for the new framework, then the existing framework will be used as baseline for the enhancement.

10 – CATT

We support overhead reduction including PDCCH in one band scheduling multiple bands and SSB/SIB in one band providing synchronization and system information for multiple bands. We agree that the former overlaps with multi-cell scheduling with single DCI in 2.1 and coordination is needed. For the latter part, we support it for overhead reduction and also beneficial for the utilization of spectrum with small bandwidth.

11 – QUALCOMM JAPAN LLC.

”SSB/SIB in one band for multiple bands” introduces the SSB/SIB-less bands where the legacy UEs cannot access, and potentially leads to congestion at the anchor band where SSB/SIB is available. Although peak data rate of a Rel-18 UE could be improved a little, we are not sure if overall system performance can be improved.

12 – Apple Hungary Kft.

13 – Futurewei Technologies

Please see our response to Question 3

14 – TELUS

Given the tiny slivers of spectrum, especially below 1 GHz (e.g., 600/700/850 MHz), it would be of interest to at least explore the options of spectrum integration.

15 – MediaTek Inc.

- On overhead reduction of PDCCH resource, this can also be achieved with the cross-carrier operation enhancement ”multi-cell scheduling by a single DCI”.
- On overhead reduction of SSB and SIB, it looks also an issue to CA with small-bandwidth carriers. In this regard, we can treat it as a generic enhancement for CA.

Overall, we expect R18 CA enhancement can focus on the following items which can provide all essential benefits for MR-MC and flexible spectrum integration:

- Cross carrier operation enhancements, including multi-cell scheduling with single DCI, FR2 SCell scheduling FR1 PCell and cross-carrier HARQ [RAN1]
- CA with relaxed timing alignment [RAN4]
- Overhead reduction of SSB and SIB for (smaller-BW) SCells [RAN1, RAN2]

16 – Intel Corporation (UK) Ltd

The non-contiguous frequency bands may be defined as different cells. further, multi-cell scheduling by a single DCI can be specified which avoid the necessity of multiple DCIs for the multiple cells.

17 – China Unicom

We support to study overhead reduction in R18. The benefits brought by overload reduction enhancement are beneficial for both single cell scenario and CA network scenario. Considering the multiple narrow bands in sub-3GHz, the reduction of overhead if the configuration of SSB/SIB for only in one DL bands, it will provided the time/frequency synchronization for multiple bands.

Based on all the above discussion, RAN2 work are needed to fulfill the requirements of Flexible spectrum integration, thus we would rather prefer a new RAN2-lead item to handle these issues in Dec.

Moderator's conclusion:

Regarding "Overhead reduction including PDCCH in one band scheduling multiple bands, SSB/SIB in one band providing synchronization and system information for multiple bands", there is some support but also considerations from many companies "PDCCH in one band scheduling multiple bands" overlaps with the objective "multi-cell scheduling with single DCI" and that, if needed, "SSB/SIB in one band providing synchronization and system information for multiple bands" can be considered as a generic CA enhancements (i.e. using the current framework).

See a possible moderator's proposal for a way forward in Section 3.

3 Intermediate round

Based on the outcome of the first round, the moderator would like to make the following proposals.

Proposal 1: "Cross carrier HARQ" is not considered for Rel-18 (with the understanding that if a "single serving cell" framework will be introduced in Rel-18, this aspect might have to be reconsidered)

Feedback Form 6: Comments on Proposal 1

1 – Ericsson LM

Fine

2 – ZTE Corporation

We are okay with proposal 1

3 – Apple Hungary Kft.

We agree with the proposal to not consider cross-carrier HARQ. We also are not sure if there should be a discussion on this new single-serving-cell 'framework', but to progress, we are ok with P1.

4 – MediaTek Inc.

We agree with moderator's understanding, cross-carrier HARQ (DL retransmissions) is one missing piece for making CA operations as efficient as a single cell, given that we already enabled offset/complementary TDD pattern in R16 and dynamic carrier switch for HARQ ACK/NACK feedback in R17. But, for reasonable R18 work load on CA enhancement, we can accept moderator's Proposal 1 to move forward.

5 – InterDigital Communications

We are fine with the proposal 1

6 – Futurewei Technologies

We are ok the proposal 1.

7 – Samsung R&D Institute UK

Support

8 – LG Electronics Inc.

It is good to not consider cross-carrier HARQ in Rel-18. Additionally, we would like to remove the last part starting from (with the understanding that.) because support of cross-carrier HARQ seems not much related to which framework is take between single serving cell framework and CA framework.

9 – QUALCOMM JAPAN LLC.

We support.

10 – vivo Communication Technology

We think cross-carrier HARQ is clearly technically beneficial in many use caes, e.g. URLLC and unlicensed operation. However, given the current discussion, we are fine to not include it in Rel-18.

11 – CATT

We are fine with proposal 1.

12 – SHARP Corporation

We are OK with Proposal 1

13 – Nokia Corporation

We support the moderator's proposal.

14 – Spreadtrum Communications

We are supportive of proposal 1.

15 – Intel Corporation (UK) Ltd We support moderator's proposal.
16 – NEC Corporation We are fine with this.
17 – VODAFONE Group Plc Fine with the moderator proposal
18 – China Mobile Com. Corporation We are fine with this proposal.
19 – Lenovo (Beijing) Ltd We support this proposal.
20 – SK Telecom We are fine with this.

Moderator's conclusion on Proposal 1: It seems that the proposal not to consider "Cross carrier HARQ" for Rel-18 is widely acceptable. A corresponding objective will not be included in a Rel-18 WI.

Proposal 2: "MR-MC with more than two active cell groups" is not considered for Rel-18.

Feedback Form 7: Comments on Proposal 2

1 – Ericsson LM Fine
2 – HuaWei Technologies Co. Fine
3 – ZTE Corporation We are okay with proposal 2
4 – Apple Hungary Kft. Agree with P2
5 – MediaTek Inc. We support moderator's Proposal 2 and would like to suggest including a RAN4 scope for enabling CA operations with relaxed timing alignment, which can practically accommodate more frequency bands in real deployments and leverage wide UE support of CA operations.

6 – Futurewei Technologies

We agree with proposal 2

7 – China Telecom Corporation Ltd.

We are generally fine with the moderator's proposal 2. We believe MR-MC with more than two active cell groups is a beneficial approach to provide higher bandwidth and capacity and also guarantee user experience, which is an attractive enhancement especially for operators. We can accept the proposal of prioritizing "flexible spectrum integration" over MR-MC considering that the support of flexible spectrum integration in proposal 3 is more urgent from operator perspective. And we can reconsider MR-MC with more than two active cell groups in later release.

8 – Samsung R&D Institute UK

We observed several objections on MR-MC, but also saw support from several operators (as well as vendors), so still think that the topic can be studied to see the actual specification impact. The topic may bring a non-negligible impact to the specifications, but the topic would be useful to operators who have several frequencies, so it would be beneficial to start studying this extension from Rel-18.

9 – LG Electronics Inc.

Fine

10 – QUALCOMM JAPAN LLC.

We support.

11 – CATT

We are fine with proposal 2.

12 – vivo Communication Technology

we are fine with the proposal.

13 – SHARP Corporation

We are OK with Proposal 2

14 – Nokia Corporation

We support the moderator's proposal.

15 – Spreadtrum Communications

We are OK for it.

16 – Intel Corporation (UK) Ltd

We are ok on Moderator's proposal.

17 – China Mobile Com. Corporation

We are fine with Proposal 2.

18 – NEC Corporation

We are fine with the proposal. Even in future, it should start with a study item to clarify the use case, benefit and expected complexity which may or may not justify the work.

19 – Lenovo (Beijing) Ltd

We support this proposal.

20 – InterDigital Communications

We prefer to have multiple active SCGs, but are ok to go with the majority view seeing that there are still some benefits... - although they are limited

Moderator's conclusion on Proposal 2: It seems that the proposal not to consider "MR-MC with more than two active cell groups" for Rel-18 is widely acceptable. A corresponding objective will not be included in a Rel-18 WI.

Proposal 3: Work on a RAN2-led WID with a short study phase, with the following objectives:

Study phase: determine whether to reuse the existing framework or introduce a "single serving cell" framework (i.e a cell using multiple consecutive or non-consecutive parts of the spectrum) for:

1. Multi-cell/carrier PUSCH/PDSCH scheduling with a single DCI
2. Reducing system overhead: SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information for multiple bands

NOTE1: if no consensus is reached on the need for a new framework, then the current framework shall be reused.

NOTE2: intra-band and inter-band, FR1 and FR2 cases should be considered

NOTE3: multi-cell scheduling with a single DCI could also cover the case of FR2 SCell scheduling FR1 PCell

Work phase: based on the selected framework, specify solutions for 1) and 2) above.

Feedback Form 8: Comments on Proposal 3 (possible WID objectives)

1 – China Mobile Com. Corporation

Compared to CA framework, single cell framework can provide the following benefits,

- Flexibility of initial access carrier selection, and load balance can be realized from initial access with low system overhead. CA can only be used for connected UEs, while single cell framework can extend multi-carrier benefit to idle/inactive mode.
- Fast activation and deactivation of carriers when there are co-located and synchronized with each other.

- Decoupling UL and DL can extend the spectrum efficiency. For example, when a high frequency DL is coupled with lower frequency UL, the coverage gap between downlink and uplink will be reduced, and spectrum efficiency for downlink carrier will be improved.

And for the concern of breaking regulation, our intention is to follow the current specified duplex mode and band combinations, therefore, no additional RAN4 work load is expected.

Considering the concern during email discussion, we can accept to take the current objectives as starting point.

2 – HuaWei Technologies Co.

The above proposal seems a good starting point.

In addition, we think the decoupling of UL and DL for initial case still worth study, in the initial round the major comments are for spectrum regulatory issues, RAN4 RF issues and changes to the existing framework. However in our view: 1) the RAN4 RF issue on inter-modulation is not a specific issue for this enhancements; 2) it is unclear what regulatory issues exactly for having this feature as CMCC also responded; 3) the potential impact needs to be first studied before concluding whether the change is significant or not. In summary we think this aspect can be included in the study as well as quite a few operators have such requirements.

Another aspect for connected mode is the BWP switching and activation/deactivation procedure for non-contiguous frequency resources in different bands. We understand companies mainly question on whether enhancements on existing framework can achieve the same target. Some companies mentioned that R16 has introduced SCell dormancy and R17 has enhanced SCell activation latency by using temporary RS for synchronization. Regarding SCell dormancy, UE can only avoid PDCCH monitoring on the dormant SCell, but it still needs to perform CSI-RS measurement/report and time/frequency tracking; regarding enhanced SCell activation latency by temporary RS, UE needs to wait for temporary RS for synchronization and perform CSI-RS measurement/report. Thus, the Rel-17 SCell activation latency is still larger and the power consumption of Rel-16 dormancy SCell is non negligible. In this case, we think there is room for further enhancements and this aspect can be studied.

We do not see need on NOTE 3, as we commented earlier, this is a corner case and we don't see specific design is required for such a case.

Thus we suggest the addition of bullet 3 and 4 in the study scope as below:

Study phase: determine whether to reuse the existing framework or introduce a "single serving cell" framework (i.e a cell using multiple consecutive or non-consecutive parts of the spectrum) for:

1. Multi-cell/carrier PUSCH/PDSCH scheduling with a single DCI
2. Reducing system overhead: SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information for multiple bands.
3. *Improvement of latency on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/(de)activation, SCell (de)activation.*

4. enhancements of initial access procedure and system information to allow configuration of resources on multiple UL bands.

3 – Deutsche Telekom AG

We fully support CMCC and Huawei's comments with regard to the UL and DL decoupleing. This is an important topic to efficiently use the operators spectrum assets and provides a flexible and efficient means to increase also the UL coverage. The topic should also cover the initial access to such a UL/DL decoupled spectrum configuration. The first priority is FDD spectrum arrangement, but we also see benefits in defintion of UL FDD and TDD for DL (e.g. a good example would be 1800 or 2100 FDD for UL and 3500 TDD for DL.

4 – ZTE Corporation

Although we think the existing framework is sufficient, we think the current proposal is a good compromise way forward. So, we are okay to have a short (e.g., 1 quarter) study phase to determine whether to reuse the existing framework or not as proposed by the moderator.

5 – Apple Hungary Kft.

We still need to understand the logic behind linking "single serving cell" framework to the following two bullets

1. Multi-cell/carrier PUSCH/PDSCH scheduling with a single DCI

In our understand, "single serving cell" is basically to extend the current serving cell configuration to allow single serving cell to cover multiple non-consecutive parts of spectrum, both intra-band and inter-band.

However, the two bullets below are talking about the enhancement for "multiple serving cells" in terms of (1) Single DCI to schedule multiple serving cells concurrently (2) Inter-band SSB less operation across different serving cells in different bands

Why the concept of "single serving cell" leads to the enhancement for "multiple serving cells"?

Regarding "1. Multi-cell/carrier PUSCH/PDSCH scheduling with a single DCI " : **In Rel-17, the performance benefit of single DCI to schedule PDSCH in two different cells was evaluated in RAN1. We feel this bullet, if studied, needs tight RAN1 involvement**

Regarding "2. Reducing system overhead: SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information for multiple bands" : **To use inter-band SSB for DL timing/frequency syncrhonizaition, tight RAN4 involvement is required to address the actual NW/UE implementation and the deployment concern/feasibility.**

So we are not sure about having RAN2 do the study as the above two are more RAN1/RAN4 related.

6 – MediaTek Inc.

We would like to ask clarification for the following questions:

- On the first item, there was study of scheduling two cells with a single DCI in R17. To accommodate different frequency resource allocation information for the two cells, two stage scheduling scheme is suggested where full scheduling flexibility for the two cells can be achieved. As the scheme is also applicable to the case of multiple cells, we suggest to revise current wording to include such design: "Multi-cell/carrier PUSCH/PDSCH scheduling from **extended signal-cell/carrier scheduling**"
- On the second item, existing specification looks able to reduce the SSB/SIB overhead by utilizing non-cell-defined SSB for (higher-frequency) SCells while accommodating UE initial access and SIB

information acquisition in (lower-frequency) PCell. It is appreciated if proponent(s) and moderation can help clarify the additional enhancement(s) needed for 2nd bullet.

- On enabling initial access with separated DL and UL, it is appreciated if proponent(s) on the idea can clarify the difference and benefit compared with having UE enter the network from a lower-frequency PCell.

7 – Futurewei Technologies

We are generally fine with the approach to have a study phase first to compare reusing existing framework and a "single serving cell" framework. To conduct such a comparison, RAN1 or RAN4 should be the lead WG instead of RAN2. And the scope of study needs to consider other aspects such as decoupling of UL and DL and initial access as the study needs to be more extensive in order to justify the needs of a new framework.

8 – SoftBank Corp.

We are fine with the moderator's proposal.

9 – Samsung R&D Institute UK

We are fine to work on the first item, but it can be a RAN1-led WI which does not require any additional TU in other WGs (e.g. RAN2). Short study phase for this item would be fine – for the evaluation we can reuse the Rel-17 assumptions as much as possible. In addition, as commented earlier, we suggest to add a clarification of "for the scenarios with > 2 cells" in order to avoid repeating Rel-17 discussions.

For the second item, we still do not see the need for additional work. Specifically, according to previous comments, the underlying assumptions should be clarified, e.g., whether the target scenario is FR1 fragmented bandwidth, how narrow bandwidth per carrier is, how large the frequency separate between bands is, etc.

For NOTE 3, as commented in the first round, there is no apparent need/deployment scenario to support this. Suggest to remove 'NOTE 3'.

10 – QUALCOMM JAPAN LLC.

We are still not convinced about the need of new framework or even the need of study for it.

For item 2 on "Reducing system overhead". We think the targeted mechanism became unclear and have the following questions. Note that in this input, we call the SSB/SIB band "Anchor band" and other multiple bands "Non-anchor bands".

Q1: Is this solution only intended for idle mode and RRC Inactive?

Q2: What exactly are the UE behavours associated with the Non-anchor bands?

- For example if paging is received on the Anchor band, random access (both UL and DL) takes place on one of Non-anchor bands?

Q3: While the UE is using a Non-anchor band, shall it continue monitoring the Anchor band simultaneously?

Q4: Can legacy UEs camp on the Anchor band?

11 – CATT

We think a WI with a study phase to compare the current framework and a new framework is a good starting point.

In addition to 1) and 2) in proposal 3, we think decoupling of UL and DL bands and enhancements of initial access should be included in the study as well.

12 – Deutsche Telekom AG

Regarding the claimed regulatory issues (for CEPT region at least):
In our understand there are no regulatory issues with such an approach, as there is nothing like a fixed duplex defined in the sense of spectrum usage (obviously for a given band it is - but this is not the discussion here). Operator are allowed to combine UL and DL spectrum of their holdings in any combination as long as the regulatory requirements in terms of masks are kept for the band.

If anyone really believes that there are regulatory issues, please clearly indicate a reference where such limitations are written ! Otherwise we can consider such claims as being motivated only as counter agruments.

Futher it is not the proposal to define news bands for the decoupled UL/DL configuration ! The proposed technical solution is based on signalling of the related UL from a DL (e.g. via SIB signalling in the DL frequency; an example is outlined in our RWS-210032 contribution).

13 – Nokia Corporation

In our view there is no justification for a work item on this area. It has not been shown that anything on top of the CA framework is needed and what enhancements would be needed and what enhancements could be achieved. We do not see this priority area for Rel-18. However, if companies are interested in studying potential enhancements further, it should be RAN1-led study item with RAN4 support (secondary) to study what enhancements are needed and why, but we do not see this as a priority when considering work load management. Enhancements should primarily be targeted on top of the existing CA framework if any enhancements are needed. Regarding the bullet 2. "Reducing system overhead: SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information for multiple bands" we are not sure anything is needed on top of the existing specifications apart from potentially extending the scellWithoutSSB capability that "Defines whether the UE supports configuration of SCell that does not transmit SS/PBCH block. This is conditionally mandatory with capability signalling for intra-band CA but not supported for inter-band CA." to apply to inter-band cases.

14 – LG Electronics Inc.

Regarding multi-cell scheduling by single DCI, as indicated earlier, we still don't see the necessity at least in the aspect of PDCCH blocking/overhead efficiency, given that multi-TTI scheduling and cross-CC scheduling are already introduced in Rel-17.

Nevertheless, if there is consensus on the necessity in other aspect, for example, control signaling across different bands, we would be open to consider it further (and it is to be RAN1-led feature).

Regarding anchor band approach for system overhead, as other companies also commented, the aspects requiring additional enhancement beyond CA framework (and multi-cell scheduling if considered) and the scenarios targeted behind seem still unclear.

Furthermore, with this anchor band approach, the impacts to system operation structure as well as UE behavior/implementation is expected to be quite large compared to the benefit from having it.

15 – Spreadtrum Communications

For Proposal 3, it is a good compromise, we are basically fine with it.

One clarification for second bullet. If the existing framework is selected after the study phase, whether or not specifying solutions for 2) is needed. From our understanding, there is no need to reducing system overhead reusing the existing framework. Or if someone could clarify additional benefits for providing DL timing/frequency synchronization, paging and system information for multiple bands from one SSB/SIB in one band on top of current CA framework.

16 – CAICT

We support to have a RAN2-led WI with a study phase. We also propose to include decoupling of UL and DL in the study phase.

17 – China Telecom Corporation Ltd.

Generally, we are fine to move forward with the compromised proposal from moderator.

Regarding the group on which to carry this work, we prefer RAN2-lead by following the agreement from chairman in RP-212608. RAN1 could be the secondary group. Because as proposed by moderator, the study phase aims to determine the framework and it could be anticipated the study phase will not stay in a long time. The major work will focus on the signaling introduction (SIB) and physical design (PDCCH improvement). So we don't see any strong necessity to move it from RAN2-lead to RAN1-lead, as it is a WI involving both groups. Regarding RAN4 impact, we see little or no RAN4 core impact.

18 – Intel Corporation (UK) Ltd

To us, objective 1 can be put as work item phase directly, not sure why study phase is needed; and the objective should be revised as 'Multi-cell~~/carrier~~ PUSCH/PDSCH scheduling with a single DCI'

For objective 2, additional justification is needed.

19 – China Unicom

We agree with the objectives moderator proposed is a very good start point, we strongly support to add these two bullets as sub-bullet 3&4 into the scope, in addition, we support RAN2-lead study item:

3. Improvement of latency on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/(de)activation, SCell (de)activation.

4. Enhancements of initial access procedure and system information to allow configuration of resources on multiple UL bands.

For bullet 3, UE can utilize the channel measurements for adjacent frequency bands and reduce the overhead for channel measurements, e.g. B5 and B8. Thus fast activation/de-activation procedures for non-contiguous frequency resources in different bands can be supported, and this will bring the benefits to save the delay for activation and de-activation.

For bullet 4, the benefits of flexible DL/UL decoupling shows as below:

1) Improved UL coverage
2) Better and more flexible usage of spectrum
3) To allow flexible paring of one DL and one UL carrier

Regarding companies comments on the logic of the framework and requirements, we understand that the logic is to address the requirement of efficient aggregation of spectrum on multiple bands. Whether to use

CA framework or single serving cell framework cannot be converged and thus it can be studied on the feasibility and gains.

For the question "UE behaviors associated with the Non-anchor bands", we think system information and paging of a serving cell can be broadcasted only in "Anchor band". The system information includes necessary information (e.g. frequency, bandwidth, SCS, RACH resource, etc.) for multiple bands. Based on this information, the UE can choose any one of carriers (including "Anchor band" and "Non-anchor bands") for initial access. The system information can be broadcast in both idle and connected mode, consequently it can apply to both connected mode transmission and initial access. This question is a bit going to solution details, we are open to discuss potential solutions further once the work starts.

20 – NEC Corporation

We think even a study phase would not be needed for 2. SSB/SIB in one band providing information for multiple bands. The drawback/concern is more important than signaling overhead optimization. We are open for 1. Multi-cell/carrier PUSCH/PDSCH scheduling with single DCI.

21 – HuaWei Technologies Co.

We'd also like to provide clarification on some comments raised by others.

Regarding the comments from some companies on what are exact impacts on supporting bullet 2, it is true that NCD SSB is already supported, however NCD SSB still has the overhead when broadcast on a certain band and the UE still needs to do the time/frequency tracking. If no SSB needs to be broadcast, the overhead can be further reduced, and this is also beneficial for UEs in connected mode to reduce activation of resources on multiple bands. More detailed information can be found in our comments in the initial round 2.3. It is also worth mentioning that the SCellwithoutSSB can only support intra-band case, and this bullet extends the support to the inter-band case.

Regarding enabling initial access with different DL and UL question from MTK, if the UE enters the network always from a lower frequency PCell, it is difficult to for those bands which only has limited UL bandwidth, e.g. up to 20Mhz, all the UEs will go to the lower frequency and lead to UL especially RACH congestion. Such UL performance limitation would also apply to the UEs in connected mode, the UE needs to rely on RRC reconfiguration and activation procedures to get work on another carrier, and as long as the PCell is not changed, the situation remains the same for the PCell from network point of view. By studying the enhancements for initial access, such limitation can be alleviated at the very beginning.

Regarding the questions from QC, we understand China Unicom already provided a good clarification. In our view the solution applies to not only to idle and inactive mode, but also to connected mode. This avoids UE tracking the timing/frequency in these modes, and also beneficial to reduce the latency of activation as temporary RS is no longer to be monitored. In addition we think legacy UEs can camp on the anchor band as long as it supports this band, as the system information can still include the information to support legacy UEs.

22 – Lenovo (Beijing) Ltd

We are OK to have a short study phase on multi-carrier PUSCH/PDSCH scheduling via a single DCI where the multiple carriers are regarded as "a single serving cell". For multi-cell PUSCH/PDSCH scheduling via a single DCI where the multiple cells are regarded as "multiple serving cells" as legacy, we propose a direct WI phase because such feature has been well evaluated in Rel-17 DSS with LLS showing significant PDCCH blocking reduction gain achieved in case of two-cell joint scheduling for DL. Furthermore, to

guarantee a reasonable DCI payload size and keep "3+1" DCI size budget, we think two-stage DCI for multi-cell scheduling should be considered in Rel-18 as two-stage SCI in Rel-16 V2X.

For overhead reduction using SSB in one band providing sync information for multiple bands, we see the careful evaluation is required including RAN4 work to ensure the SSB can be accurately applied for other bands. So a study phase is required for this evaluation.

23 – VODAFONE Group Plc

Agree with the moderators proposal as a starting point but the first objective may need RAN1 involvemente. We share the same comment of DT on the UL and DL decoupleing

24 – Ericsson LM

In addition to the issues we brought up earlier, we think bullet number 2 would have considerable RAN4 impact and RAN4 is already going to be overloaded in Rel-18.

Bullet 2 for intra-band FDD cases works already in low bands and the gain to add this in inter-band for high bands is has not been shown.

As there is large impact of the "single cell concept" we assume that if anything should be done, we should rely on potential enhancements for the existing CA-framework.

Moderator's conclusions on Proposal 3:

- There was some support for the suggested formulation for the WID objectives, but also significant concerns, mainly on the need to consider a new "single serving cell" framework
- On the specific proposal to specify "Multi-cell PUSCH/PDSCH scheduling with a single DCI" it seems that there could be wide support, if the current CA framework is retained, possibly with the clarification that scenarios with more than 2 cells show be targeted
- On the specific proposal to reduce the system overhead by ensuring that "SSB/SIB in one band could provide DL timing/frequency synchronization, paging and system information for multiple bands", there were comments on whether this is already possible today / whether we just need to extend the UE capabilities for this
- There was a further proposal to "Improve of latency on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/(de)activation, SCell (de)activation", which did not receive too many comments
- There was a further for "enhancements of initial access procedure and system information to allow configuration of resources on multiple UL bands." that received some support but that, at least in the moderator's understanding, would be objected if it could not fit in the current CA framework

The moderator suggests to first of all consider the following 2 non-controversial (or less controversial) objectives for a WID (see Section 4.1):

Objective 1: Specify a solution for multi-cell PUSCH/PDSCH scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]

- intra-band and inter-band, FR1 and FR2 cases should be considered

Objective 2: Study whether anything else is needed so that SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different band, apart from introducing a new UE capability for this (i.e. on top of the existing capability for intra-band CA) and, if needed, specify a solution accordingly [RAN1 or RAN4 led??]

Then the discussion could continue to see whether any other enhancement, under the existing CA framework, could be considered to allow an even more flexible use of DL and UL resources (See Section 4.2)

Proposal 4: In addition to the above scope, please provide any comments on whether some limitations (e.g. as in NOTE1 above) can be applied to additional potential objective(s), to make them more acceptable.

Feedback Form 9: Comments on Proposal 4 (possible limitations to introduce additional objectives)

4 Final round

4.1 Non/less controversial Work Item objectives

1. Specify a solution for multi-cell PUSCH/PDSCH scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]

   - intra-band and inter-band, FR1 and FR2 cases should be considered

2. Study whether anything else is needed so that SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different band, apart from introducing a new UE capability for this (i.e. on top of the existing capability for intra-band CA) and, if needed, specify a solution accordingly [RAN1 or RAN4 led??]

Companies are invited to provide further comments, if any, on the 2 WID objectives above

Feedback Form 10: Comments on the non/less controversial WID objectives

1 – Charter Communications

We support both of the proposed objectives.

2 – Futurewei Technologies

We are quite surprised to see this revised objective after the intermediate round of discussions. From our reading of the inputs during the intermediate round, majority of the companies are generally fine with the proposal to have a study face to compare reusing the existing framework and introduction of a ”single serving cell” framework (i.e a cell using multiple consecutive or non-consecutive parts of the spectrum). Most of the comments are on how to improve the wording of the objective and whether RAN1 and RAN4 should be part of the study. The final round should be based on majority view to finetune the intermediate round proposal 3. A suggested revision is provide here:

Proposal:

Work on a RAN2-led WID with a study phase together with also RAN1 and RAN4, with the following

objectives:

Study phase: determine whether to reuse the existing framework or introduce a ”single serving cell” framework (i.e a cell using multiple consecutive or non-consecutive parts of the spectrum) for:

1. Multi-band PUSCH/PDSCH scheduling with a single DCI

2. Reducing system overhead: SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information for multiple bands

3. Other aspects including UL and DL coupling flexibility, and latency reduction for utilizing non-contiguous frequency resources in different bands.

NOTE1: if no consensus is reached on the need for a new framework, then the current framework shall be reused.

NOTE2: intra-band and inter-band, FR1 and FR2 cases should be considered.

3 – Apple Hungary Kft.

While we are completely inline with the proposals, we are willing to progress. Pls see the below some more comments:

For obj2: it looks to us to be more in the RAN4 domain.

4 – Samsung R&D Institute UK

For the first objective, having a short study phase would be preferable. The current proposal (with the wording of ‘also’) looks misleading. Our intention was to restrict the scenario with > 2 cells (not including 2 cells). Our suggestion would be:

1. Study and specify scheduling of PDSCHs/PUSCHs on multiple cells using a single DCI format [RAN1]

- Identify the supported number of cells for the scheduling.
- Consider both intra-band and inter-band CA operation.
- Consider both FR1 and FR2.

For the second objective, the benefit of SCell without SSB/SIB is not clear at all, e.g. how much overhead can be reduced. Also, timing/frequency synchronization is more of RAN4 scope and paging/system info aspects are RAN2 area. Hence, the responsible working group should be updated accordingly, e.g., [RAN4, RAN2] if we work on this.

5 – Nokia Corporation

We do not see need for these type of enhancements. Need for these type of enhancements have not been shown.

1. However, we could accept the objective proposal 1 as a compromise, as a continuation of the discussions that took place in the RAN1 DSS WI in Rel-17, but didn’t lead to any specification. This would be RAN1-lead work.

2. The objective 2 proposal could be OK, but it is not clear if there is anything else to do apart from new capability (RAN2) and new UE requirements (RAN4), and if so, what would the role of RAN1 be. From the RAN1 perspective this is likely to be just a new UE capability but the limiting factor for such capability is RAN4 requirements and especially UE RF implementations and UE RF requirements.

6 – Intel Corporation (UK) Ltd

We agree with moderator's suggestions on objective 1.

For objective 2, as commented by Mediatek, NCD-SSB can be used to reduce the overhead. For the study, what requirement/target we want to achieve? To reduce the overhead further compared with NCD-SSB?

7 – QUALCOMM JAPAN LLC.

We are fine with the objective 1. "multi-cell PUSCH/PDSCH" however could be confusing. We understand it is still one PDSCH/PUSCH per cell.

1. Specify a solution for multi-cell PUSCH/PDSCH (one PDSCH/PUSCH per carrier) scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]

For the objective 2, we do not think sufficient technical justification was given so far. "Majority support" neither is a good enough reason to overload WGs. We share the view from other companies that the feasibility of having time/frequency synchronization reference for other band is not really RAN2 domain. This is similar to the past discussion; RAN2 could not have concluded on the feasibility of SSB-less SCell.

As we commented previously, the current objective, apart from Nokia's suggestion on the UE capability, is very vague. But we understand from the current description which focuses on DL synchronization and overhead reduction. we assume neither UL (no timing/frequency reference mentioned) nor RRM on SSB/SIB-less bands.

8 – HuaWei Technologies Co.

We are in general fine with the proposal from the moderator.

We support bullet 1 with the wording improvement to make it more generic :

Specify a solution for **multi-band** PUSCH/PDSCH scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]

Regarding bullet 2, we support the intention to extend intra-band SCell without SSB to inter-band cases. From our analysis, the main change is to add UE capability to support inter-band case and also adds clarification on the conditions in 38.331 when SSB need to be sent. When introducing intra-band SCell without SSB in Rel-15, RAN1 has already completed the work and the extension to inter-band case does not require any RAN1 specification changes. In this case, the impact is small and straight forward, and thus we propose to update bullet 2 as below:

2. **Specify the case that** ~~Study whether anything else is needed so~~ SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different band, **including** ~~**apart from introducing**~~ **a new UE capability for this (i.e. on top of the existing capability for intra-band CA) and clarification on the conditions to send SSB**~~, if needed, specify a solution accordingly~~ [RAN2 ~~RAN1 or RAN4 led??~~]

Regarding Intel's comment, we have already responded in the intermediate round. see below:

Regarding the comments from some companies on what are exact impacts on supporting bullet 2, it is true that NCD SSB is already supported, however NCD SSB still has the overhead when broadcast on a certain band and the UE still needs to do the time/frequency tracking. If no SSB needs to be broadcast, the overhead can be further reduced, and this is also beneficial for UEs in connected mode to reduce activation of resources on multiple bands. More detailed information can be found in our comments in the initial round 2.3. It is also worth mentioning that the SCellwithoutSSB can only support intra-band case, and this bullet extends the support to the inter-band case.

9 – China Telecom Corporation Ltd.

We are fine with both of the 2 objectives. Regarding the group-led, we posted our view in 4.3

10 – NEC Corporation

We are OK with the bullet 1.

For the bullet 2, we are still unsure about the justification. The point is not as described, but *at most* to study whether it is feasible and useful that SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different band? We are not convinced of the need for the bullet 2, as no justification is seen so far (or summarized). However, if this is to be studied, RAN4 should lead and study its feasibility.

11 – LG Electronics Inc.

Regarding the first objective, as indicated earlier, we can accept the objective if other companies are all OK to consider it.

Regarding the second objective, firstly as companies already commented, it is to be mainly in RAN4 area.

Apart from WG, we share the same view with other companies (thus not supportive to the objective) since the overhead benefit from having such SSB/SIB-less SCell is unclear and the use of NCD-SSB could be sufficient to reduce the overhead.

12 – CATT

It seems that the current proposal is based on reusing the existing CA framework. We share the similar view as Futurewei that we prefer the previous proposal to have a study phase between the existing framework and a new framework.

13 – CAICT

We are general fine with moderator's proposed objectives.

14 – Spreadtrum Communications

We are fine with the proposal. For second bullet, it should be RAN4 led, RAN1 can be involved if necessary.

15 – China Mobile Com. Corporation

In addition to overhead reduction gains, SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different bands can also achieve energy-saving for both base stations and terminals.

For base stations, without SSB/SIB/paging on some of the carriers, they can get more sleep chances on those carriers, and energy saving can be realized.

For UEs, the RRM and SIB information obtained from one band can be directly applied to the other bands. So when UE switches from one carrier to other carriers, for example, due to different slicing services provided by different carriers, it does not need to perform sync or obtain SIB from the those carriers, the power consumption can be reduced, both for idle/inactive or connected mode.

On the other hand, even for carriers that have their own SSB/SIB information, if SSB/SIB can be omitted or the periodicity can be increased for some cases, both gNB and UE can save power for such carriers.

So we propose the following modification for the proposal,

- Specify a solution for multi-cell PUSCH/PDSCH scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]
  - intra-band and inter-band, FR1 and FR2 cases should be considered
- Study enhancement to reduce unnecessary SSB/SIB transmission[RAN1, RAN4]
  - SSB/SIB in one band provide DL timing/frequency synchronization, paging and system information for a different band
  - Reduced SSB/SIB transmission in some carriers

16 – Ericsson LM

On objective 1:

The moderator mentioned in the previous round that ”FR2 SCell scheduling for PUSCH on FR1 PCell” is included in the multi-cell scheduling with single DCI solution, but we still prefer a separate bullet to include this. At least, it should be made explicitly clear for this objective that the PDCCH can be on an SCell.

On objective 2:

While some overhead reduction could be achieved from this functionality, we see the main gains would be in network energy saving. Hence, we believe the implications of introducing such carriers will anyway be studied in the NW energy efficiency study item. Based on the outcome of that study item, one can discuss what to standardize. Hence, we suggest to drop this objective for now.

17 – Lenovo (Beijing) Ltd

We support specifying multi-cell PUSCH/PDSCH scheduling via a single DCI including FR1 and FR2. We’d like to make it clearer that unlicensed spectrum in FR1 and FR2 are included in the objective.

We support a study SSB/SIB1 overhead reduction first on evaluation including RAN4 work to ensure the SSB can be accurately applied for other bands.

18 – MediaTek Inc.

Thanks for moderator’s summary. We support Objective 1 with some revision but cannot agree Objective 2.

For Objective 1, Rel-17 has conducted study. It is reasonable to consider the solutions studied in Rel-17 as starting point, which also avoid duplicated work time. Regarding ”a single DCI”, we see there is proposal in Rel-17 that is based on two stage DCI. Before the study is concluded, we suggest to revise ”a single DCI” to ”a single PDCCH”. By the above the following revised Objective 1 is suggested:

- Specify a solution for multi-cell PUSCH/PDSCH scheduling with a single ~~**DCI**~~ **PDCCH**, also for scenarios with more than 2 cells [RAN1]
  - intra-band and inter-band, FR1 and FR2 cases should be considered
  - **Consider solutions studied in Rel-17 as starting point**

For Objective 2, current version looks that companies have no consensus on whether this is a real issue. Justification should necessary before we can scope and agree the item.

19 – Continental Automotive GmbH

We support the Objective #1 and follow the moderator´s suggestion for the Objective #2.

20 – VODAFONE Group Plc

We share the same comments as Intel, it would be good to have a clear justification for Objective #2 in the WID

21 – ZTE Corporation

We are generally okay with the objectives.

For the first objective

We think both 2 cells and more than 2 cells cases should be covered, but we are okay to identify the maximum number of cells as part of the work. We think it is obvious that if a solution is developed for >2 cells case, it would of course also cover the 2 cell case.

For the second objective:

We support the objective in principle, but we think RAN4 should be involved to check the feasibility (especially since we want to extend this to inter-band, we think RAN4 might even need to take the leading role and have to decide up front, for which bands (if any) this is feasible).

Our understanding is that the second objective allows to study feasibility and benefits of this solution to IDLE and INACTIVE UEs and would enable SSB/SIB-less cell/bands, where system information (including RACH configuration) for a SIB-less cell/band can be broadcast on another cell/band.

22 – SoftBank Corp.

We are fine with the moderator's proposal. For objective #2, we also see the need of RAN4 involvements.

23 – SK Telecom

We are fine with the proposal. For second objective It seems like we should discuss it with RAN4.

Moderator's conclusions:

Regarding Objective #1 the following main comments were made:

- on the number of cells that could be scheduled simultaneously: e.g. two or more cells, strictly more than two, etc. The moderator thinks that this can be addressed by stating that the maximum number of cells scheduled simultaneously shall be identified during the work.
- that it should be clarified that there is still one PDSCH/PUSCH per cell.
- to change "multi-cell" into "multi-band". However the intention is to cover both intra-band and inter-band scenarios, so it seems better to stick to "multi-cell".
- to change "with a single DCI" into "with a single PDCCH". However the moderator believes it would be less controversial to stick to "DCI" (as this was used from the beginning of the discussion), with the understanding that the detailed solution can of course be discussed in RAN1.

The following revision for an apparently non-controversial Objective #1 is then suggested:

1. Specify a solution for multi-cell PUSCH/PDSCH scheduling (one PDSCH/PUSCH per cell) with a single DCI~~, also for scenarios with more than 2 cells~~ [RAN1]
    - Identify the maximum number of cells that can be scheduled simultaneously
    - Consider both intra-band and inter-band CA operation
    - Consider both FR1 and FR2 ~~cases should be considered~~

Regarding Objective #2:

- There is some general support, even if some companies claim that the benefits would be limited (or note that in any case things like RRM on SSB-less cells/bands would not be supported)
- In any case it seems that this could be a relatively simple extension of the concept of Scells without SSB (already supported in intra-band CA) to the inter-band CA case, although RAN4 should check the feasibility (e.g. for which bands this could be done)

The following rewording for a possibly non-controversial Objective #2 is then suggested:

2. Introduce support for Scells without SSB in inter-band CA (so that an SSB in one band can provide DL timing/ frequency synchronization for an Scell in a different band), via the following steps:

- identify for which bands this is feasible and the related UE requirements [RAN4]
- introduce the related UE capability and signalling support [RAN2]

4.2 Possible additional Work Item objectives

Companies are invited to provide comments on other possible enhancements, under the CA framework, that could allow an even more flexible use of DL and UL resources, e.g.:

- Improvement of latency on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/(de)activation, SCell (de)activation
- enhancements of initial access procedure and system information to allow configuration of resources on multiple UL bands.

Feedback Form 11: Comments on other possible WID objectives

1 – Charter Communications

We support for FR1, improvement of latency on (de)activation procedure for non-contiguous frequency resources in different bands. This is particularly relevant for operation in shared spectrum with incumbent users.

2 – Futurewei Technologies

Please see our response in section 4.1

3 – Apple Hungary Kft.

For bullet 1 in Q4.2: *We already have SCell activation latency reduction in Rel-17 which covers the non-contiguous freq resources in diff bands. We are not sure if anything else is needed.*

For bullet 2 in Q4.2: *Initial access related enhancement is sensitive since it is done before we can report our UE capability (unless we introduce UE capability reporting during RACH procedure). It is preferable not to discuss it. Otherwise, we need to put into the objective that corresponding WG also needs to finish the design to allow initial access related enhancement to be UE optional feature.*

4 – Samsung R&D Institute UK

For the first objective, we still fail to see the need for further latency improvement over Rel-16/17 CA framework and existing BWP switching operation.

For the second objective, we have concerns on the backward compatibility with respect to the enhancements of initial access procedure.

5 – Nokia Corporation

Utilizing CA framework is good but first it should be identified what really is the limiting factor in different cases. In many cases UE RF constraints are likely to limit the flexibility and activation latency rather than the current CA framework and solutions. Studies should be started in RAN4 from the RF constraints and what kind of enhancements would be feasible from the RF implementation perspective. If RAN4 identifies that enhancements would be feasible and beneficial, further studies could be conducted in RAN1/RAN2 how such improvements could be achieved. These objectives should not be part of any work item.

6 – Intel Corporation (UK) Ltd

Agree with comments above, the use case, justification of this is not very clear to us.

7 – QUALCOMM JAPAN LLC.

We do not think sufficient explanation for the need of new framework has been provided throughout the discussion on this item so far.

8 – HuaWei Technologies Co.

We support to include these two bullets and the benefits have already been explained in previous two rounds. We'd like to repeat as below (hope companies can read):

- For connected mode, based on SSB/SIB in one band providing DL timing/frequency synchronization, the improvement of latency on (de)activation procedure or shorted activation delay can be achieved since no time/frequency tracking procedure or temporary RS is needed any more (note that **Rel-17 still requires temporary RS**) .
- For idle/inactive mode, based on SSB/SIB in one band providing DL timing/frequency synchronization, paging and system information (e.g. frequency, bandwidth, SCS, RACH resource, etc.) for multiple bands, enhancements of initial access procedure can be achieved, i.e., UE can choose any one of the UL carriers for initial access according to the traffic or coverage. The benefits at least include flexible offloading from initial access and the corresponding access delay reduction thanks to congestion avoidance.

To support the above two bullets, the major impact is on signaling and thus it is RAN2 led item with RAN1 involvement.

Regarding Apple's and Samsung's comment, it is unclear what specific issue it is. We have introduced RACH partitioning for different features, and UEs who support a particular feature can use the relevant RACH resources for initial access; otherwise the UE uses legacy RACH resources to initial access. The discussion here is similar, the UE not supporting this new enhancement simply uses legacy mechanism for access. If companies have worries, we can add a note as below for the second sub-bullet:

NOTE: backward compatibility needs to be taken into account for this objective.

9 – Deutsche Telekom AG

We disagree with the moderators conclusion that the further work on UL / DL flexibility should be solely based on the CA framework.

Multiple operators (CMCC, DT, VF, ...) indicated in this discussion that the limitations and overhead of the CA framework does not allow flexible usage of operators spectrum assets. There is also not an "associated regulatory issue" as wrongly claimed by some companies.

10 – Deutsche Telekom AG

We propose to remove the condition "under the CA framework".

11 – China Telecom Corporation Ltd.

We would like to propose to include the 1st bullet for "improvement of latency…" into Work Item objectives, since one of the motivation from flexible spectrum integration is to improve the flexibility of multi carriers operation, thus faster SCell (de)activation is necessary to achieve the flexibility. As our understanding, for low frequency neighbor bands such as 700+800+900, if both Pcell and Scells are always activated , it will cost additional power consumption/PA inefficiency and potential signaling redundancy. Further enhanced Scell (de)activation would be a good solution to make the Scell (de)activation adapted fast to service request and scheduling.

12 – NEC Corporation

There is no clear justification seen yet. At least, both need to be studied first. We prefer to drop them.

13 – LG Electronics Inc.

We agree with other companies (thus not supportive to those objectives) since the necessity/justification of the enhancement beyond existing CA framework/IA procedure is not clear.

14 – CATT

We support both of the bullets. As commented in section 4.1, we propose to have a study phase on framework so we agree with the comments from DT to remove "under the CA framework".

15 – CAICT

We are fine to include these two bullets as part of RAN2 led works.

16 – Ericsson LM

We don't think any additional objectives are needed.

17 – Spreadtrum Communications

We still cannot be convinced by the justification and use cases for this flexible use of DL and UL resources. Especially, BWP switching and fast SCell (de)activation have been supported in Rel-15/16, which is also under the CA framework.

18 – China Mobile Com. Corporation

We are supportive for the above two objectives.

With SSB/SIB in one band provide DL timing/frequency synchronization for a different band, the (de)activation procedure for such bands can be reduced since measurement one one band can be reused to other bands.

Furthermore, with the system information including RACH configuration for non-anchor carriers obtained from anchor carriers, it is natural for UE to initiate random access directly on non anchor carriers.

19 – Lenovo (Beijing) Ltd

We don't support multiple active BWPs on one serving cell as it is against NR framework and leads to high implementation effort for UE.

In addition, to guarantee a reasonable DCI payload size and keep "3+1" DCI size budget, we think two-stage DCI for multi-cell scheduling should be considered in Rel-18 as two-stage SCI in Rel-16 V2X.

20 – MediaTek Inc.

Thanks for moderator's summary.

For the first bullet, Rel-16 and Rel-17 have conducted related enhancements. The remaining enhancements should be only RAN4 work on requirements. We are open for RAN4 work and would like to point out joint consideration with RAN4 WI for Rel-18 is necessary to avoid duplicated works.

For the second bullet, we think Rel-15 UE can already leverage SUL for initial access, and the additional benefit for this enhancement should be justified further. Before the justification, we are not supportive of this item.

21 – ZTE Corporation

As noted above, we think that the system information including RACH configuration for the non-anchor carriers obtained from anchor carriers is a use case that could be studied as part of the second objective in section 4.1 (i.e., to study the benefits and feasibility of this in specific bands based on RAN4 input).

22 – China Unicom

In general, the motivation to enhance the flexibility of multi carriers operation can be satisfied with these two bullets, **so we strongly support to include these 2 bullets in the objectives**, and we can explain the benefits again as below to show how it works:

For bullet 1, the reduction of system overhead (e.g. RS) and latency (e.g. simplify the time/frequency tracking procedure) can be achieved.

For bullet 2, UE can get better service experience (e.g. coverage enhancement for UL). UE can utilize the DL information for multi-bands and choose a desirable band for uplink access from the multiple available UL bands (e.g. based on coverage), thus the enhancements of initial access procedure and system information for the UE can be achieved.

And we also think “under the CA framework” can be removed due to that UL / DL flexibility should not be solely based on the CA framework.

23 – SoftBank Corp.

Our original expectation was to do something better which cannot be achieved by CA framework. We also prefer to remove “under the CA framework”.

24 – TELUS

Improvements need to beyond the current CA framework, we support removal of the ”under the CA framework” part.

Moderator’s conclusions:

For the first objective discussed in this section (”Improvement of latency on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/(de)activation, SCell (de)activation”):

- there are very split views: some companies claim it’s essential while other companies really see no need for this.
- In any case the proponent further clarified how this relates to Objective #2 in the previous section: if SSB in one band can provide DL timing/frequency synchronization for another band, latency improvement on (de)activation can be achieved since no time/frequency tracking procedure or temporary RS is needed any more.

The moderator suggests to list the following as a [controversial] objective in the draft WID description, with the intention to have basis to continue the discussion in the future if needed:

3. [controversial] Based on SSB in one band providing DL timing/frequency synchronization for another band, specify solutions for latency improvement (not requiring temporary RS) on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/ (de)activation, SCell (de)activation

For the second objective discussed in this section, ”enhancements of initial access procedure and system information to allow configuration of resources on multiple UL bands”:

- There is some support, and also companies claiming that we don’t need to stick to the existing CA framework
- On the other hand, there are many company who don’t see the need for this (and also don’t want to deviate from the CA framework)

The moderator suggests to consider the following [maybe not too controversial?] objective in the draft WID description, as possible compromise to do something for this in Rel-18:

4. [maybe not too controversial] Study feasibility and implications (e.g. that legacy devices cannot access a SSB/SIB-less cell) to use SSB/SIB in one cell to provide information (including e.g. RACH configuration) to allow Idle/Inactive UEs to perform initial access in another (intra-band or inter-band) cell [RAN2]

4.3 Leading WGs and TU allocation

Considering the list of the likely agreeable WID objectives so far, it seems that the Work Item could be RAN1-led.

Companies are invited to provide their view on the overall leading WG and on a possible TU allocation, taking into account the suggested objectives so far.

Feedback Form 12: Comments on the leading WG and on the TU allocation

1 – Nokia Corporation No work item is justified. If there is interest to study this area, most of the work would be RAN4-led studies to understand RF constraints, especially UE RF implementation and requirement constraints and what kind of enhancements would feasible from the UE RF perspectives. The only item which could be RAN1-led work item is the following objective "Specify a solution for multi-cell PUSCH/PDSCH scheduling with a single DCI, also for scenarios with more than 2 cells [RAN1]" but necessity of this enhancement is not clear.
2 – Intel Corporation (UK) Ltd Agree with Nokia that if there is interest to study, objective 1 should be RAN1 led item, and objective 2 should be RAN4.
3 – QUALCOMM JAPAN LLC. Agree this is now RAN1/4 domain.
4 – HuaWei Technologies Co. As explained above, this is a RAN2-led item.
5 – China Telecom Corporation Ltd. As we commented in intermediate round, we think this is a RAN2-led WI. For Non/less controversial Work Item objectives, -the multi-cell PUSCH/PDSCH scheduling is RAN1-led -the SSB/SIB-less is RAN2-led, regarding study on the other impacts, it may have RAN4 performance part impact. For the possible additional Work Item objectives, as we propose to include the 1st bullet for "improvement of latency…" which we think is RAN2-lead topic.

6 – CATT We agree with Huawei and China Telecom that this is a RAN2-led item.
7 – CAICT We think the main enhancements(4 bullets listed in 4.1 and 4.2) are RAN2 related and the leading WG should be RAN2.
8 – Ericsson LM Assuming that we only have objective #1 from section 4.1, this should be RAN1 led item. Then a 0.5 TU allocation throughout the release is likely needed.
9 – Lenovo (Beijing) Ltd Considering the current objectives, we support RAN1 lead this WI. Regarding TU allocation, maybe one TU is sufficient for each meeting.
10 – MediaTek Inc. Given the major work should be on Objective 1, we think this should be a RAN1-led WI with study phase.
11 – ZTE Corporation We also think this WI should be RAN1 led. We also think this 1 TU per meeting would be enough.
12 – China Unicom We support RAN2-lead.

Moderator's conclusion: Based on the comments expressed and on the likely non-controversial objectives, this could be a RAN1-led item (1 TU per meeting) with RAN4 involvement (0.5 TU) and very limited RAN2 involvement. RAN2 role would be bigger (and could also become predominant) if the last [maybe not too controversial] objective were finally considered.

5 Conclusions

The following likely non-controversial objectives are suggested for a WID on CA/DC enhancements:

1. Specify a solution for multi-cell PUSCH/PDSCH scheduling (one PDSCH/PUSCH per cell) with a single DCI [RAN1]
    - Identify the maximum number of cells that can be scheduled simultaneously
    - Consider both intra-band and inter-band CA operation
    - Consider both FR1 and FR2
2. Introduce support for Scells without SSB in inter-band CA (so that an SSB in one band can provide DL timing/ frequency synchronization for an Scell in a different band), via the following steps:
    - identify for which bands this is feasible and the related UE requirements [RAN4]

- introduce the related UE capability and signalling support [RAN2]

Although more controversial, the following additional objectives are also suggested to be added to the draft WID description (e.g. to have basis to continue the discussion at RAN#94e / in the future):

3. [controversial] Based on SSB in one band providing DL timing/frequency synchronization for another band, specify solutions for latency improvement (not requiring temporary RS) on (de)activation procedure for non-contiguous frequency resources in different bands, e.g. BWP switching/ (de)activation, SCell (de)activation

4. [maybe not too controversial] Study feasibility and implications (e.g. that legacy devices cannot access a SSB/SIB-less cell) to use SSB/SIB in one cell to provide information (including e.g. RACH configuration) to allow Idle/Inactive UEs to perform initial access in another (intra-band or inter-band) cell [RAN2]

Based on the likely non-controversial objectives, the WID is suggested to be a RAN1-led item (1 TU per meeting) with RAN4 involvement (0.5 TU) and very limited RAN2 involvement. RAN2 role would be bigger (and could also become predominant) if the last [maybe not too controversial] objective were finally considered.