**3GPP TSG RAN Meeting #90e RP-20xxxx**

**Electronic Meeting, December 7- 11, 2020**

**Agenda item:** 9.8.10

**Source:** Qualcomm Incorporated (Moderator)

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**Title:** Moderator's summary for email discussion [90E][29][IAB\_DC]

**Document for:** Approval

**Release:** Rel-17

# Introduction

The discussion handles:

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| Email thread on finding a way forward on DC scenarios in IAB.  Goal: Generate an agreeable way forward.  Input contributions covered:  2533, 2626, 2672.  Moderator: Georg Hampel. |

The contributions RP-202533, RP-202626 and RP-202672 discuss the support for intra-carrier DC in Rel-17 IAB. All three contributions propose that TSG RAN preclude support for intra-carrier DC for Rel-17 IAB since not enough time would be available within present TU budgeting to handle the technical issues. One contribution claims that intra-carrier DC would not be supported by the Rel-17 IAB WID.

RAN#89e already had a discussion on this topic (RP-202083). In the discussion, 8 out of 15 companies were in favor for intra-frequency DC, 5 companies were opposed while 1 company needed more information. No agreement was reached. There was further no agreement if intra-carrier DC for IAB was compliant with the WID or not.

In this follow-up discussion in RAN#90e, the moderator would like to make further progress. The following is proposed:

**On compliance of intra-carrier DC with Rel-17 WID:** The RAN#89 discussion already indicated that the Rel-17 IAB WID was not sufficiently clear on the support of intra-carrier DC for IAB. For that reason, we will not spend further time on discussing the wording of the Rel-17 WID.

**On the size of the specification effort for intra-carrier DC for IAB:** In the prior discussion, some companies claimed that only little work was needed while others believed it was a major effort. The discussion did not try to scope the effort. We will therefore use the RAN#90 follow-up discussion to identify the main issues that need to be addressed for intra-carrier DC for IAB by each RAN WG. This exercise will provide a better understanding on what needs to be done, and it might make it easier to converge on this topic for Rel-17.

To keep focus, the following assumptions are made:

* Inter-carrier DC is supported in Rel-17 IAB.
* Intra-carrier DC is not supported in Rel-16 IAB.
* The discussion only focuses on intra-carrier DC for IAB, not for UEs.

The contributions to RAN#90e raised the following issues related to intra-carrier DC for IAB:

**RP-202533** claims that there is no verification on the feasibility of intra-carrier DC for IAB. The contribution does not discuss any issues that would need to be handled.

**RP-202626** made the following claims:

* Dynamic scheduler coordination between parent IAB-nodes would be necessary. No details were giving on what this would entail and which WG would be involved.
* For FR2, DC synchronization requirements would imply severe, if not impossible, restrictions in the IAB-deployment.No details were given on what such FR2 DC synchronization requirements would have to entail and why this would be severe or impossible.
* Implementation of intra-carrier DC would require extensive work that was not accounted for in the present time budgeting. No details were given on what this work would include.

**RP-202672** claims that the following issues would need to be addressed by RAN1:

* Revisiting IAB-MT assumptions on DL synchronization and UL timings,
* Parent nodes sending conflicting D/U/F indications in DCI 2\_0 for same IAB-MT resource,
* Parent nodes sending conflicting soft resource availability in DCI 2\_5 for same IAB-DU resource on IAB-node’s child link,
* Parent nodes indicating different number of guard-symbols in MAC-CE.

The contributions further claimed that the following issues would have to be addressed by RAN3:

* Resource coordination between gNBs for topology redundancy scenarios, where MCG and SCG links are controlled by different (donor or non-donor) gNBs.

The contribution further claims that RAN4 would need to investigate the potential impact of intra-carrier DC. No details were giving on what this would involve.

# Discussion

## Initial discussion: Issues to be handled for intra-carrier DC for IAB

The following aim to identify the main issues to be addressed by the individual RAN WGs. For each issue, we need to understand:

1. The underlying problem to be solved,
2. The main aspects to be addressed by each WG to solve the problem,
3. The adverse effects an implementation-only solution might have, e.g., on performance, inter-vendor interoperability, etc.

The questions below are based on the issues raised in contributions to RAN#90e. Companies are invited to discuss additional issues as well.

**Q1: In your view, what needs to be done for inter-parent-node scheduler coordination to support intra-carrier DC for IAB? Please explain the problem to be solved, aspects to be addressed by each WG, and impact if done via implementation only.**

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| **Company** | **Comment** |
| AT&T | “Scheduler coordination” is a broad term, but at a fundamental level this would require ensuring that the scheduling of the two parent links does not 1) violate the duplex constraint within the IAB node (i.e. half duplex or full duplex) and 2) does not violate the half duplex constraint within the backhaul link (i.e. simultaneous DL Rx and UL Tx by the MT function). This can be done on a semi-static basis and requires some specification effort to support inter-vendor IAB deployments. In our understanding this work would first be carried out in RAN1 to define the requirements and general framework for the coordination and RAN3 would determine what updates (if any) to the existing DU resource coordination signaling would be required (e.g. to support intra vs. inter donor operation). In our view, the scope of scheduler coordination for intra-carrier DC is similar to what would be required for inter-carrier DC, at least when it comes to ensuring the duplex constraint at the IAB node is not violated, since even in Rel-16 it is possible to indicate different multiplexing capabilities for different DU/MT carriers (e.g. half duplex may still be required even for inter-band operation between parent nodes). |
| vivo | For resource scheduling coordination between MCG and SCG, the scheme discussed in multi-TRP transmission can be baseline. In Rel-17 multi-TRP enh., it has been discussed that UE can camp on a single carrier and connect to two BSs, the related solution can simply be reused for IAB intra-carrier DC.  For resource management of DU, the TDD/resource type indication should be coordinated as well. However, this issue should be addressed for intra-band inter-carrier DC as well.  Therefore, we think no specific issue needs to be addressed regarding resource management for intra-carrier DC. |
| NTT DOCOMO | When IAB operate with Carrier A (including Frequency resource A-1+A-2), while IAB-MT is allocated Frequency resource A-1 from Parent node 1 and Frequency resource A-2 from Parent node 2, scheduler coordination may be necessary since A-1 and A-2 may or may not be able to overlap without causing mutual interference. However, tight scheduler coordination to appropriately handle resource overlapping would be complex. |
| Huawei | Our understanding is that dynamic scheduler coordination are not possible for both intra-carrier and inter-carrier DC. However, the problems that needs be solved are similar for inter-carrier intra-band DC and intra-carrier intra-band DC.  For inter-carrier intra-band DC, the IAB-MT needs to handle **scheduling collisions due to half duplex constraint** on the backhaul link if the IAB-MT is scheduled to Tx in one CG and Rx in the other CG simultaneously. The scheduling collision can be resolved by prioritizing the scheduling from MCG. However, this may not be sufficient if there is no coordination between the MCG and SCG. In the worst case, the SCG does not get any opportunity for Tx/Rx which defeats the purpose to configuring DC. Semi-static coordination across MCG and SCG should be supported such that the above scheduling confliction can be avoided. One possibility is to configure available/schedulable resources for the IAB-MT on a given CC such that the IAB-MT can understand which CG is prioritized in case of scheduling collision. This problem would need some more discussions in RAN1 and RAN3 may also need to be involved for the case of inter-donor operation to check whether any coordination between CU is needed.  Similar to inter-carrier intra-band DC, for intra-carrier intra-band DC, the IAB-MT needs to handle scheduling collisions due to half duplex constraint if the IAB-MT is scheduled to Tx in one CG and Rx in the other CG on the same CC. The solutions proposed to resolve the scheduling conflict for Case 2 can be applied for Case 3 as well. |
| Samsung | Regarding the analysis on RP-202533 by moderator, it may mislead about our view on intra-carrier DC. As discussed in the tdoc, our intention was to point out there is no common understanding on how intra-carrier DC operates because dual connectivity in 3GPP has always assumed the use of separate carriers since LTE. One example which is unclear to us would be how to coordinate scheduler decision between MCG and SCG for intra-carrier DC because there is no such coordination for inter-carrier DC so far. It is one of aspects which needs group’s common understanding if the intra-carrier DC is feasible. On the other hand, even if intra-carrier DC is deemed feasible, whether or not it is something beneficial to support in Rel-17 IAB is a separate matter which has not been estimated by any evaluations. |
| Ericsson | Duplexing coordination is just the very beginning of resource coordination and must be assumed to reflect duplexing capabilities. If parent nodes share time-frequency resources that can't be used simultaneously, of course inter-parent-node scheduler coordination is required. In inter-band DC, this is implicitly not necessary. Any already specified form of intra-carrier transmission from multiple nodes has requirements on coordination and/or timing. Furthermore, different to existing schemes, IAB is missing inter-DU connectivity for such coordination. |
| Nokia | Scheduler coordination in intra-carrier DC can be identified under two main cases:   1. No/less coordination between parent DUs, and IAB MT may have to handle resource conflict scenarios. 2. Some coordination between parent DUs, and IAB MT does not expect to have resource conflict scenarios.   RAN1 shall prioritize the first case, where some discussion of resource multiplexing rules is needed, and the impact on other WGs is minimal. In general, we see that intra-carrier DC can be still handled within the existing TU allocations for RAN1.  For the second case, coordination is only necessary in scenarios where configured and available resources overlap between both DUs. One option is to leave such coordination to implementation.  Another option is to have a joint solution with CLI/Interference handling for IAB. In scenarios where potential collisions can occur, existing interference management techniques (e.g., CLI/RIM) may be extended to assist in avoiding collisions. RAN1 could strive for single solution for such extension of coordination considering both intra-carrier DC and IAB CLI/interference avoidance (which is anyways ongoing discussion in RAN1). We expect that minimal discussion will be needed in RAN3 to address coordination. |
| ZTE | The inter-parent-node scheduler coordination could be divided into following two cases:   1. Inter-donor: the two parent nodes of IAB-MT connect to two donor CU. In this case, MCG and SCG needs to coordinate the resource configuration of the two parent node to avoid the scheduling conflict and interference between MCG link and SCG link. In addition, the resource configuration of co-located IAB-DU also need to be coordinated to avoid the half duplex restraints of IAB node. It should be noted this semi-static resource division for MCG and SCG may lead to inefficient resource usage. However, if dynamic scheduling is considered, the latency requirement could not be met since the coordination between the two parent nodes requires the signalling transmission via donor CUs.   Intra-donor: the two parent nodes of IAB-MT connect to the same donor CU. In this case, the semi-static resource division for the two parent node may be controlled by donor CU. However, it is hard to realize the intra-carrier dynamic scheduling since there is no direct connection between two parent DUs and the latency can not be guaranteed. |

**Summary Q1: Coordination of inter-parent-node scheduling**

There seems to be agreement that MCG/SCG resource coordination is necessary.

Some companies believe that this effort can be done within existing TUs. Some companies claim that this effort is too complicated and cannot be done at all.

The Moderator is not convinced that this is an unsurmountable effort since intra-carrier coordination has already been done for DSS. Intra-carrier NR DC could just use this solution as a blueprint. Also, on F1, the Rel-16 gNB-DU resource configuration is already available and can be enhanced as necessary.

One company claims that inter-DU connectivity would be necessary. The Moderator does not understand why this is needed since the MN and SN can coordinates resource allocation.

Overall, the following efforts seem to be necessary:

* RAN1 needs to define requirements for inter-parent-link resource coordination to account for duplex constraints within IAB-node and half-duplex constraint on each link. Some aspects of this coordination are already necessary for intra-band inter-carrier DC. DSS can be used as a blueprint.
* RAN3 needs to provide Xn signaling between MN and SN based on RAN1’s requirements.

**Q2: In your view, what needs to be done for the coordination of DCI 2\_0 signaling for D/U/F indication among parent nodes to support intra-carrier DC for IAB? Please explain the problem to be solved, aspects to be addressed by each WG, and impact if done via implementation only.**

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| **Company** | **Comment** |
| AT&T | The problem is similar to Q1 except instead of involving the donor nodes to resolve the conflicts, it is just the IAB nodes themselves which determine the slot indication on a dynamic basis instead of semi-static basis (but with the same goal of avoiding scheduling conflicts which violate the duplex constraint). RAN1 could handle this objective by itself and define child/parent node behavior to avoid or handle potential conflicts (within the framework already provided by the semi-static coordination addressed in Q1). Again as in Q1, ensuring that duplex constraints are not violated by the multiple parents is a common objective for both intra-carrier and inter-carrier DC. |
| vivo | Even for inter-carrier intra-band scenario, indication from DCI 2\_0 may incur troublesome TDD conf. Considering that UE may be subject to HD constraint as well for inter-carrier intra-band case, this is not specific issue for intra-carrier DC.  It is noted that such issue is already under discussion in RAN1. |
| NTT DOCOMO | When IAB-DU operate with Carrier A (including Frequency resource A-1+A-2), while IAB-MT is allocated Frequency resource A-1 from Parent node 1 and Frequency resource A-2 from Parent node 2, single TDD pattern should be applied to Carrier A for the IAB-node. On the other hands, each of two parent nodes can indicate D/U/F dynamically with DCI 2\_0 for the IAB-node, and different D/U/F indication for Carrier A may happen. Therefore, a mechanism on how to handle the D/U/F indication for Carrier A with two parent nodes needs to be considered. |
| Huawei | DCI format 2\_0 is used to indicate the slot format of a given serving cell. In case of intra-carrier DC, it is possible that the MCG or SCG indicate two different slot formats for the same CC. Note that it is not always feasible to coordinate the signaling of DCI format 2\_0 between the MCG and SCG considering the signaling delay between the two parent nodes.  Overall, in addition to the issue in Q1, i.e. the IAB-MT may need to handle scheduling conflict due to half duplex constraint on the backhaul link, the IAB-MT needs to handle the slot format indication conflict from the MCG and SCG. More discussion is needed in RAN1. |
| Samsung | It seems Q2 assumes a coordination with DCI format 2\_0 for intra-carrier DC is needed. Our view is that it should be first checked whether or not the coordination with DCI 2\_0 signaling is required based on common understanding on how to operate intra-carrier DC. |
| Ericsson | Multi-parent scenarios without proper coordination of DCI format 2\_0 between parent cannot work. This is also valid for inter-carrier, intra-band and solutions can be equally applied. The question on coordination needs for DCI format 2\_0 is very much connected to what kind of multiplexing is assumed between parent node, or not, and is therefore not entirely addressable at this point. |
| Nokia | As mentioned under Q1, RAN1 can assume two cases.  First case,   * Problem: Coordination between parent nodes for dynamic signaling (e.g. DCI 2-0) is not possible/feasible to avoid resource conflicts at IAB-MT. * Solutions for resource multiplexing shall be addressed only in RAN1. RAN1 shall define the resource multiplexing rules for receiving DCI 2-0 via both parent nodes that support intra-carrier DC.   Second case,   * Problem: Some coordination between parent nodes for dynamic signaling to avoid conflicts at the IAB MT. * Solutions for receiving DCI 2-0 from both parents or via single parent without conflicts and applying that for both parent links shall be defined in RAN1. If coordination handled by specification, some work is expected from RAN3.   As the work and scope is straightforward, the workload is not significant. Therefore, no additional TUs are required in WG1 or WG3 to address DCI\_2.0 operation. |
| ZTE | The coordination of DCI 2\_0 signalling to support intra-carrier DC is used for dynamic scheduling. It requires the coordination across two parent nodes. Moreover, inter-donor CU scenario requires the coordination between two donor CUs to alleviate the collision. Considering the potential latency of BH link and Xn interface, we think it is not feasible to support the coordination of DCI 2\_0.  On the other hand, certain resource collision rules may be defined at IAB node when receiving DCI 2\_0 from both parent node. However, without coordination between parent node, the resource collision may frequently happen. In this case, the resource utilization of the IAB network is of low efficiency and the IAB network may even fail to work. |

**Summary Q2: Coordination of inter-parent-node DCI 2-0 indications**

It seems there is agreement that the handling of conflicting DCI 2-0 indications from MCG and SCG parents needs to be addressed in RAN1. Some companies believe that this is straightforward, others think it is difficult to align with the scheduling constraints discussed in Q1. Once company believes it is entirely impossible. One company claims that this effort has already started in RAN1.

The Moderator believes that the handling of conflicting inter-parent-node DCI 2-0 indications is already necessary for inter-carrier inter-band DC. Therefore, no additional effort is necessary for intra-carrier DC.

**Q3: In your view, what needs to be done for the coordination of DCI 2\_5 signaling for soft-resource-availability indication among parent nodes to support intra-carrier DC for IAB? Please explain the problem to be solved, aspects to be addressed by each WG, and impact if done via implementation only.**

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| **Company** | **Comment** |
| AT&T | Similar scope as Q3, however it should be noted that soft resources are not strictly essential for IAB. As in Rel-16, RAN1 may not need to specify all aspects of the determination of the availability of soft resources at the child node and leave potential optimizations up to implementation. |
| vivo | Similar as DCI 2\_0, the issue exists both for inter-carrier and intra-carrier scenarios, which is under discussion in RAN1. |
| NTT DOCOMO | When IAB-DU operate with Carrier A (including Frequency resource A-1+A-2), while IAB-MT is allocated Frequency resource A-1 from Parent node 1 and Frequency resource A-2 from Parent node 2, single configuration of H/S/NA is indicated by CU for Carrier A of IAB-DU. On the other hands, although dynamic indication of IA/INA with DCI 2\_5 can be indicated by each of two parent nodes, single soft resource availability should be determined for a soft resource. Therefore, a mechanism on how to handle the availability of Soft IAB-DU resource based on DCI 2\_5 indication with two parent nodes needs to be considered. |
| Huawei | DCI format 2\_5 is used to indicate the availability of IAB-DU soft resources. Since the content of DCI format 2\_5 is configured semi-statically, it is possible to configure availability indication of IAB-DU soft resources for different IAB-DU cells from MCG and SCG in a non-overlapping manner, i.e. the availability indication from MCG and SCG are for different IAB-DU cells. Even if there is an overlap, i.e. availability indication is from two CGs, it may be sufficient to define a rule to determine the availability of IAB-DU soft resource, e.g. IAB-DU can Tx or Rx on a soft resource only if it is indicated as available from both MCG and SCG. More discussions in RAN1 is required as agreed in RAN1#103-e.  **Agreement**  The explicit indication of soft resources by DCI Format 2\_5 is supported for multi-parent scenarios in Rel-17.   * FFS: Whether additional enhancements over the Rel-16 solution are needed   In summary, the issue of DCI format 2\_5 may not specific for intra-carrier DC. |
| Samsung | Similar to Q2, our view is that it should be first checked whether or not the coordination with DCI 2\_5 signaling is required based on common understanding on how to operate intra-carrier DC. |
| Ericsson | DCI format 2\_5 is addressing a different dimension of the problem in controlling DU resources through parent nodes. Where DCI format 2\_0 controls whether a certain resource is D/U/F, DCI format 2\_5 has a more dynamic property and is not suitable for DU coordination. |
| Nokia | Dynamic DCI 2\_5 signaling per parent link may be used to communicate availability of resources. Discussion on DCI 2\_5 is more critical than DCI 2\_0 if we are to efficiently use resources within IAB network.  Similar to Q2, we shall discuss two possible cases.  First case,   * Problem: Coordination between parent nodes for dynamic signaling (e.g. DCI 2-5) is not possible/feasible to avoid conflicting resource indication for IAB-DU. * Solutions for deriving availability of DU soft resources shall be defined if the IAB MT expecting different indications from parent nodes. RAN1 shall define the rules for receiving DCI 2-5 via both parent nodes that support intra-carrier DC.   Second case,   * Problem: Some coordination between parent nodes for dynamic signaling to avoid conflicts of using soft resource at the IAB DU. * Solutions for receiving DCI 2-5 from both parents or via single parent without conflicts and applying that at IAB DU shall be defined in RAN1. If coordination handled by specification, some work is expected from RAN3. RAN3 only need to provide a means for loosely coordinating parent DUs to avoid overlapping resources.   The first case mentioned above is anyway needing some discussion for the IAB MTs that support multi-DCI based multi-TRP operation (which support non-ideal BH conditions where dynamic coordination is not feasible). Given the commonalities with MIMO multi-TRP and intra-carrier DC, the same solution may be considered for both multi-TRP and other intra-carrier DC scenarios with very little additional definition. |
| ZTE | Similar to DCI 2\_0, the coordination of DCI 2\_5 signalling to support intra-carrier DC requires the coordination across two parent nodes. Moreover, inter-donor CU scenario requires the coordination between two donor CUs to alleviate the collision. Considering the potential latency of BH link and Xn interface, we think it is not feasible to support the coordination of DCI 2\_5.  On the other hand, when receiving DCI 2\_5 from both parent nodes, the collision rules may be defined at IAB node. However, it may lead to misunderstandings of resource availability between the parent node and IAB node. It does not fundamentally solve the issue. |

**Summary Q3: Coordination of inter-parent-node DCI 2-5 indications**

It seems there is agreement that the handling of conflicting DCI 2-5 indications from MCG and SCG parents has to be addressed in RAN1. Some companies believe that this straightforward while others believe it is difficult if not undoable.

* RAN1 needs to address handling of conflicting DCI 2-5 indication from MCG and SCG parents.

**Q4: In your view, what needs to be done for parent-to-child timing synchronization to support intra-carrier DC for IAB? Please explain the problem to be solved, aspects to be addressed by each WG, and impact if done via implementation only.**

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| **Company** | **Comment** |
| AT&T | The timing requirements are both a function of deployment considerations (distance between parent nodes) and IAB node implementation (shared or common hardware at the MT for the MCG/SCG links). In our view, specification work is not essential for this objective (other than documenting requirements). Optimizations are certainly possible, but just as T\_delta in Rel-16 is a helpful “tool in the toolbox” for achieving OTA-based timing alignment, they would not be required for DC with IAB. |
| vivo | In Rel-17, such issue can be left to NW deployment. It can be assumed that the distances from IAB node to the two parent nodes are comparable. If enh.is needed, it can be captured in later release. |
| NTT DOCOMO | When IAB-DU operate with Carrier A (including Frequency resource A-1+A-2), while IAB-MT is allocated Frequency resource A-1 from Parent node 1 and Frequency resource A-2 from Parent node 2, IAB node may receive TA1/T\_delta1 from Parent node 1 and TA2/T\_delta2 from Parent node 2. Since the IAB node needs to derive a single DU Tx timing based on TA and T\_delta, a mechanism on how to derive DU Tx timing with two parent nodes needs to be considered. |
| Huawei | Our understanding is main specification effort is that RAN4 needs to define the timing synchronization requirement for intra-carrier DC deployment. However, we do understand 3us cell phase error requirement among IAB-nodes may put some limitations to the practice usage of intra-carrier DC in FR2. |
| Samsung | In case of inter-carrier DC, there are RAN4 requirements (e.g., TS38.133 for UE) for a relative receive timing difference (MRTD) and a relative transmission timing difference (MTTD) between MCG and SCG. Especially, minimum MRTD requirements for synchronous cases are the following: 33us in case of inter-band synchronous EN-DC and 3us in case of intra-band synchronous EN-DC. Also, 33us for inter-band synchronous NE-DC and 8us (for both MCG and SCG on FR2) in case of inter-band synchronous NR-DC. In our view, it should be checked how to operate DC in a same carrier taking into account the RAN4 requirements. |
| Ericsson | A DU is required to be synchronized with its neighbor DUs to an accuracy of 3 µs. GNSS synchronization will typically result in a higher but still limited accuracy; nevertheless, there are no requirements for such improved accuracy. At the same time, intra-carrier DC will require an accuracy of <0.6µs (FR2) in order to fit both parent transmissions within the CP. Different parent-node ISDs would further decrease that margin. With these inaccuracies and having imperfect BH connectivity (different to m-TRP or co-located DC), it is not possible to guarantee operation for any difference in parent node ISD. |
| Nokia | Each IAB DU must already meet gNB synchronization requirements to remain transparent to legacy R15 UEs. No additional synchronizations requirements are envisioned for IAB intra-frequency DC. Simultaneous SDM or FDM transmission form both parent DUs is not anticipated in R17 IAB.  No further work would need to be done for timing in WG1 provided that SDM or FDM operation is limited to one parent DU at a time.  If the parent-to-child timing synchronization assume T\_delta signaling via multiple parents, that discussion is not only restricted to the intra-carrier DC case as inter-carrier DC case may also have to consider that. Anyway, Rel-16 discussed that already, and left to IAB node implementation to select one or both parent T\_delta indications to adjust DL Tx timing. |
| ZTE | As far as we know, RAN4 only studied the inter-band NR DC in FR2 as of now. For the intra-band DC, only ENDC scenario was discussed with the assumption that the connected DUs are collocated. So RAN4 needs to be involved to define the synchronization requirement for intra-carrier DC. Then, RAN1 should be involved to study how to support the intra-carrier DC synchronization requirement. We think synchronization accuracy requirement between the intra-carrier DC parent DUs should be stringent, especially for SDM and FDM resource multiplexing. It requires a lot of efforts in both RAN1 and RAN4. |

**Summary Q4: Parent-to-child time synchronization**

Some companies believe that nothing needs to be done (except some documentation work). Another company claims that RAN1 needs to address the handling of conflicting T\_delta signaling from both parent nodes. Another company points out that this issue is the same for inter-carrier as for intra-carrier DC. The Moderator agrees that there this issue needs to be addressed for intra-band already. Therefore, no additional effort would be necessary for intra-carrier DC.

Two companies believe that time synchronization better than 3us would be necessary for FR2. One of these companies claims that time synchronization better than 0.62us would be required, and that this could be achieved via GNSS. This would imply that at least for GNSS deployments no further work is needed.

**Q5: In your view, what other issues need to be addressed to support intra-carrier DC for IAB? Please explain the problem to be solved, aspects to be addressed by each WG, and impact if done via implementation only.**

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| **Company** | **Comment** |
| AT&T | We want to highlight that the critical need from an operator perspective, is for multi-parent support in Rel-17 which aligns with **practical deployment** scenarios for IAB. Requiring that different carriers or frequency bands are assigned for different parents diminishes the usefulness of the feature by limiting the backhaul capacity and creates an undesirable tradeoff in the network between performance and robustness. In our assessment, intra-carrier DC is the shortest path to achieving this objective – but we can understand that working on optimizations for different corner cases may also take up valuable WG time. Our suggestion for a compromise is to identify a subset of requirements/restrictions (i.e. FR2 only, assumptions on network timing synchronization, reusing inter-carrier DC features as the baseline) that can keep the workload to the bare minimum and deliver a solution for the intra-carrier scenario in Rel-17, which is the most relevant scenario for early IAB deployments, instead of pushing it out into the future. |
| Huawei | Our understanding is that at least RAN4 needs to be involved to define DC band combinations. Besides, some RRM and RF requirements needs to be defined for intra-carrier DC and specification effort should be carefully assessed. |
| Ericsson | Even if there are seemingly simple solutions to some of the problems addressed above, there is no consensus about those agreements. Neither is there a consensus about IAB architecture for a possible intra-carrier operation, also is evident by other companies’ comments. In conclusion, a seemingly “simple” specification effort will soon consume a substantial effort.  Furthermore, we do not share the view that intra-carrier DC will be more efficient than inter-carrier DC utilizing the same spectrum. Considering the limitations being discussed above, scheduler coordination, and resource utilization will be substantially worse in comparison to the intra-carrier case. Additionally, it would only require no/very limited specification impact.  Given the constraint of intra-carrier operation, a more attractive solution would be multi-MT, *disregarding any interference between the multiple MTs*. Multi-MT was discussed and not agreed in the last plenary meeting. However, that discussion concerned general dual parent operation why companies may have different views on the usefulness of multi-MT for the intra-carrier case. Additionally, in order to simplify specification work, and to eliminate the uncertainty of support for intra-band, inter-carrier DC, which is per RAN1 agreement conditioned on reusing solutions for inter-carrier inter-band DC, multi-MT could be selected for all intra-band dual parent operation.  Finally, we think specification of multi-MT is more realistic and more in line with Rel-17 TU allocations. |
| Nokia | The primary effort for intra-carrier DC shall be first on agreeing the assumptions on coordination. As mentioned in Q1-Q3, required specification enhancements shall also consider the case of no coordination between IAB parents, and only RAN1 work is expected here to solve open issues of intra-carrier DC.  If some coordination is assumed, then as mentioned under Q1-Q3, there would be some impact in both RAN1 and RAN3, but that is expected to be minimal.  In any case, we believe that these features may be addressed within the existing TUs allocated per WG. Most of the discussions on multiplexing rules or conflict handling are directly related to Rel-16 discussions and there is nothing new that RAN1 shall define rather than extending certain discussions.  Finally, we tend to agree with the additional points made by AT&T that highlights the importance of the intra-carrier DC where splitting resources for multiple parents (inter-carrier DC) will impact the capacity achievable for the BH link. |
| ZTE | For the intra-carrier DC, the resource multiplexing between two parent links need to be considered. It is not clear whether TDM, FDM, SDM or all of them should be studied.  On the other hand, Rel-17 IAB WID aims to study the resource multiplexing between one parent link and one child link. When it comes to two parent links and one child link in intra-carrier scenario, the resource multiplexing scheme need to be re-discussed.  Nevertheless, we think a lot of RAN1 efforts are required to address these issues. |

**Summary Q5: Other issues**

The Moderator believes that the operators’ views should be the driving factor for this 3GPP effort. From that perspective, network vendors should consider on how at least a baseline solution of intra-carrier DC could be supported in Rel-17.

The Moderator emphasizes that a large fraction of RAN2/3 work in Rel-17 is dedicated to topological redundancy, e.g., for load balancing and robustness. Dropping intra-carrier DC (or dual-parenting) would certainly limit the efficacy of these RAN2/3 redundancy solutions.

The Moderator believes that all issues of intra-carrier-DC also apply to intra-carrier multi-MT. Therefore, if intra-carrier DC cannot be supported in Rel-17, inter-carrier multi-MT won’t be either.

RAN4 work on band combinations is certainly necessary but this also applies for inter-carrier intra-band DC.

## Intermediate discussion: Aspects to be handled for intra-carrier DC for IAB

Based on the initial round, the following efforts were identified for intra-carrier DC for IAB:

**Coordination of inter-parent-node scheduling**

* RAN1 needs to define requirements for inter-parent-link resource coordination to account for duplex constraints within IAB-node and half-duplex constraint on each link. Some aspects of this coordination are already necessary for intra-band inter-carrier DC. DSS can be used as a blueprint.
* RAN3 needs to provide Xn signaling between MN and SN based on RAN1’s requirements.

**Q11: Please provide feedback/comments on these efforts**

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| **Company** | **Comments** |
| AT&T | We agree with the assessment and want to emphasize the work should strive for a common framework with intra-band inter-carrier DC to minimize the workload. We are not sure if explicitly mentioning DSS as a baseline is necessary as the effort for IAB may actually be even more straightforward since both parent links are NR-based in this case. |
| vivo | Agree. |
| ZTE | As far as we know, RAN1 has agreed to support inter-carrier intra-band scenario for FR2 and reuse the solutions for supporting inter-carrier and inter-band. However, it is not yet determined whether specific enhancement for inter-carrier intra-band DC is introduced in Rel-17. So it is not accurate to say that the coordinations are already necessary.  On the other hand, we think the semi-static resource division for MCG and SCG with may lead to inefficient resource usage. For dynamic inter-parent-node scheduling, the latency requirement could not be met since the coordination between the two parent nodes requires the signalling transmission via donor CUs. So it is not feasible to support the inter-parent-node scheduling. |
| Ericsson | We think there are some underlying assumptions which have not been agreed upon.  The first assumption is to actually specify intra-carrier DC for IAB. We don't think that is the case and we don't think there is consensus to do so.  The second assumption has to do with the backhaul assumption for the DUs. For a robust intra-carrier DC solution which provides capacity gains over inter-carrier DC the parent DUs must have very tight coordination which implies ideal backhaul. Without tight coordination backhaul capacity would be limited and an undesirable tradeoff in the network between performance and robustness is introduced. Tight coordination, while offering a more efficient and robust intra-carrier DC solution, on the other hand puts restrictions on the practicality of the deployment.  We would prefer an open discussion on the backhaul assumption as it will dictate the amount of work needed and which solutions to pursue. |
| Nokia | Agree.  RAN1 consider only intra-CU scenario for DC.  If RAN2/3 agree on inter-CU scenarios, RAN1 may need to define the parameter set that would be included in any RAN3 Xn signaling.  Also, the second bullet can be clarified as “**RAN3 needs to provide Xn signaling (if inter-CU scenario is also supported) between MN and SN based on RAN1’s requirements**” |
| Huawei | We agree with the assessment that more discussion in RAN1 and RAN3 would be needed to support intra-carrier DC and some aspects are similar to inter-carrier intra-band DC.  In addition, some discussion are required to check both synchronous or asynchronous intra-carrier DC can be supported and whether the existing UL power control schemes can be reused.  It is not clear how the solutions discussed in DSS can be reused hence we prefer not to refer to DSS. |
| Intel | We are not sure if DSS can be used as a blueprint unless tight coordination and very accurate network synchronizations between LTE and NR are guaranteed. In our understanding, DSS is supported in co-located scenario without any support in Xn signaling.  The level of coordination for intra-carrier DC should be different from inter-carrier DC because in case of intra-carrier DC, resource scheduling in one parent node will affect the other parent node and hence more tight coordination is required. Actually, the exact resource scheduling coordination between two parent nodes have not been fully discussed in RAN1.  It should be also investigated whether Xn signaling via donor CU can provide tight coordination for intra-carrier DC. |
| Qualcomm | We agree with the identified RAN1 and RAN3 work to enable the required resource coordination. In addition to the proposed coordination, RAN1 may further define simple conflict resolution rules (e.g. based on prioritization) as a fallback solution. |
| Futurewei | It is sensible that leveraging RAN1/3 works on duplex constraints for intra-band inter-frequency DC can limit the extra efforts needed for intra-frequency DC. And starting the works with intra-CU intra-frequency DC scenarios may help achieve practical progress to address operators’need. |

**Coordination of inter-parent-node DCI 2-0 indications**

No additional effort was identified for intra-carrier DC over intra-band inter-carrier DC.

**Q12: Please provide feedback/comments on these efforts**

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| **Company** | **Comments** |
| AT&T | Agree. As mentioned by some companies, RAN1 work can also cover the even simpler cases where no coordination is required. |
| vivo | Agree.  DCI 2\_0 indication issue is common for both intra-band inter-carrier DC and intra-carrier DC, i.e. no additional effort due to intra-carrier DC support. |
| ZTE | As we mentioned before, it is not yet determined in RAN1 whether specific enhancement for inter-carrier intra-band DC is introduced in Rel-17. On the other hand, the coordination of DCI 2\_0 signalling to support intra-carrier DC requires the coordination across two parent nodes. Inter-donor CU scenario further requires the coordination between two donor CUs to alleviate the collision. Considering the potential latency of BH link and Xn interface, we think it is not feasible to support the coordination of DCI 2\_0. |
| Ericsson | Contrary to what the moderator states in the introduction, there is no unconditional agreement that inter-carrier DC is supported in Rel-17. The RAN1 agreement regarding inter-carrier DC states:  ***Agreement***  *From a RAN1 perspective, resource multiplexing and coordination is supported for the following DC scenarios in Rel-17.*   * *Inter-carrier, inter-band* * *Inter-carrier, intra-band is additionally supported at least for FR2*    + *At least to the extent it reuses solutions for supporting Inter-carrier, inter-band*   We fail to see how any of what is proposed by the moderator is included in the above agreement. Hence, even if we agree to the moderator’s conclusion about what work needs to be done, coordination of DCI 2\_0 indication, even for inter-carrier DC, is not included in RAN1 in Rel-17.  Even if inter-carrier DC is to be agreed, it is quite possible to see different solutions for intra-carrier DC and inter-carrier DC. For example, for all inter-carrier scenarios, we can implicitly associate a carrier to a link. In principle, both links can operate independently (a common assumption for the DC specification). There are many aspects related to this that are not met by intra-carrier DC, coordination of DCI 2\_0 is a minimum. |
| Nokia | Agree.  Even for intra-band inter-carrier DC, IAB MT may get semi-static configuration (Rel-15/16) such that the IAB MT monitors DCI 2\_0 via only single parent. As dynamic coordination (if DCI 2\_0 is sent more often via both links) is not feasible, we think that RAN1 should clarify the IAB MT behavior for monitoring DCI 2\_0. |
| Huawei | Agree |
| Intel | The basic mechanism of using DCI 2\_0 might be the same for intra-carrier DC and inter-carrier DC. However, for intra-carrier, we think additional consideration is needed on how to handle e.g. whether same resource can be scheduled or not. |
| Qualcomm | We agree. |
| Futurewei | Agree. It is therefore important to clarify the intra-frequency DC aspect in WID, so that RAN1 can take it into proper consideration. |

**Coordination of inter-parent-node DCI 2-5 indications**

* RAN1 needs to address handling of conflicting DCI 2-5 indication from MCG and SCG parents.

**Q13: Please provide feedback/comments on these efforts**

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| **Company** | **Comments** |
| AT&T | Agree. We also want to highlight that if handled in context with solutions for inter-parent scheduling/DCI Format 2\_0 signaling, the extent to which these collisions occur can already be minimized. |
| vivo | Agree.  There is certain commonality between intra-band inter-carrier DC and intra-carrier DC for D/U/F indication while the restriction in case of intra-carrier DC could be more stringent. |
| ZTE | Similar to DCI 2\_0, the coordination of DCI 2\_5 signalling to support intra-carrier DC requires the coordination across two parent nodes. Moreover, inter-donor CU scenario requires the coordination between two donor CUs to alleviate the collision. Considering the potential latency of BH link and Xn interface, we think it is not feasible to support the coordination of DCI 2\_5.  On the other hand, when receiving DCI 2\_5 from both parent nodes, the collision rules may be defined at IAB node. However, it may lead to misunderstandings of resource availability between the parent node and IAB node. It does not fundamentally solve the issue. |
| Ericsson | The moderator’s statement that RAN1 only needs to specify coordination of DCI 2\_5 indication conflicts assumes a certain solution that has not been agreed to. Hence, we think it is not possible to reduce the problem to the statement above as well as any other solution statement.  In addition to our response to Q11 and Q12, we think that the highly dynamic use of DCI 2\_5 indication does not lend itself to be used in a high latency environment with multiple wireless backhaul links. Thus, this is an example that we need to agree on the assumptions on the backhaul before agreeing on the severity of this problem. |
| Nokia | Agree.  As mentioned before, as DCI 2-5 is mainly for dynamic resource sharing between nodes, it is important that RAN1 discuss the coordination and conflict handling mechanism. |
| Huawei | Agree. As commented previously, the conflict of DCI 2\_5 indication from MCG and SCG is not a particular issues for intra-carrier DC, it can happen even in case of inter-band DC. However, some further discussion would be needed in RAN1 whether any specification effort is necessary to address the possible conflict. |
| Intel | We agree that those issues for DCI 2\_5 are already necessary for inter-carrier DC. |
| Qualcomm | While we agree RAN1 should address this concern, we believe it is not specific to intra-carrier DC (e.g. it may happen in case of intra-band inter-carrier DC too). Furthermore, it is expected a very simple solution using the concept of “implicit determination of availability of SOFT resources” can be adopted to address such conflicts. |
| Futurewei | Agree. Clarifying the intra-frequency DC aspect in WID is helpful to reduce redundant works in RAN1. |

**Parent-to-child time synchronization**

For the handling of conflicting T\_delta signaling, no additional effort was identified for intra-carrier DC over intra-band inter-carrier DC.

No additional effort was identified for time synchronization for deployments using GNSS.

**Q14: Please provide feedback/comments on these efforts**

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| **Company** | **Comments** |
| AT&T | Our preference is to not spend time optimizing T\_delta signaling for this scenario. As mentioned by Nokia, this issue was previously discussed and left to implementation in Rel-16. |
| vivo | Agree.  The existing T\_delta configuration based on desired and provided guard symbol MAC CEs can already provide good flexibility and whether additional flexibility is needed could be further addressed in ongoing IAB duplexing enhancement in RAN1. For baseline intra-carrier DC, additional work for guard symbols can be assumed not needed. |
| ZTE | As far as we know, RAN4 only studied the inter-band NR DC in FR2 as of now. For the intra-band DC, only ENDC scenario was discussed with the assumption that the connected DUs are collocated. So RAN4 needs to be involved to define the synchronization requirement for intra-band intra-carrier DC. Then, RAN1 should be involved to study how to support the intra-carrier DC synchronization requirement. We think the synchronization requirement may not be the same for inter-carrier and intra-carrier DC. For intra-carrier DC, the synchronization accuracy requirement between the intra-carrier DC parent DUs should be more stringent, especially for SDM and FDM resource multiplexing.  For the deployment using GNSS, it is not always available. That is the reason that we spent major effort on OTA solutions in Rel-16. GNSS should not be used to evaluate the specification effort of intra-carrier DC in IAB. |
| Ericsson | We don’t share the moderator’s problem formulation as being solely related to T\_delta. As pointed out before, there are physical deployment limitations to intra-carrier DC that are not considered, and specification limitations to how well parent nodes can be aligned.  The moderator states that “Two companies believe that time synchronization better than 3us would be necessary for FR2. One of these companies claims that time synchronization better than 0.62us would be required, and that this could be achieved via GNSS. This would imply that at least for GNSS deployments no further work is needed.”  This, we believe is a misunderstanding, at least if it is based on our comments. Orthogonality among subcarriers within a carrier requires maintaining the circular convolution. This is achieved by aligning all subcarriers to (at least) within the CP, and less than that if channel dispersion is also taken into account. Hence, the timing alignment requirement of 0.6µs for intra-carrier DC. Regardless if synchronization is achieved by GNSS or by OTA, the specified time synchronization is still 3µs for network nodes. There is no higher synchronization requirement on GNSS synchronized nodes and for that reason, they cannot be expected to perform better than the specified 3µs. As network nodes, IAB nodes follow that specification requirement. Since the specified 3µs timing inaccuracy is much larger than the required timing accuracy of <0.6µs, it will be impossible to guarantee the latter given the specified accuracy of the former. Even for nodes using GNSS for time synchronization.  Furthermore, we believe this is contrary to inter-carrier DC, where different carriers are used and, hence, no such stringent time synchronization requirement is necessary. |
| Nokia | Agree. No additional effort is required. |
| Huawei | Our view is that at least some discussion is needed regarding whether two separate T\_delta is allowed from MCG and SCG. If so, how the DL Tx timing should be determined. The discussion may be related to whether synchronous or asynchronous intra-carrier DC can be supported |
| Intel | We tend to agree. But more important issue to discuss is how to achieve synchronization between parents node because intra-carrier DC requires more stringent synchronization requirement than inter-carrier DC. |
| Qualcomm | We agree. Similar concern is valid even for inter-band DC and has been discussed to some extent during Rel-16 RAN1 (i.e. how to determine DU DL TX timing in the presence of multiple synchronization sources). RAN1 can further discuss this issue in Rel-17. Although, an implementation-specific solution may also be adopted without any further standardization effort. |
| Futurewei | We agree. It is normal that some RAN4 works would be needed for the supported bands, and operators can provide input to focus RAN1/4 works on the targeted scenarios. |

**Other issues**

The Moderator believes that the operators’ views should be the driving factor for this 3GPP effort. From that perspective, network vendors should consider on how at least a baseline solution of intra-carrier DC could be supported in Rel-17.

The Moderator emphasizes that a large fraction of RAN2/3 work in Rel-17 is dedicated to topological redundancy, e.g., for load balancing and robustness. Dropping intra-carrier DC (or dual-parenting) would certainly limit the efficacy of these RAN2/3 redundancy solutions.

The Moderator believes that all issues of intra-carrier-DC also apply to intra-carrier multi-MT. Therefore, if intra-carrier DC cannot be supported in Rel-17, inter-carrier multi-MT won’t be either.

RAN4 work on band combinations is certainly necessary but this also applies for inter-carrier intra-band DC.

**Q15: Please provide feedback/comments on the Moderator’s summary**

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| **Company** | **Comments** |
| AT&T | We agree that multi-MT likely requires a similar evaluation in RAN1 and perhaps can be considered as a special case of intra-carrier DC with some additional hardware implementation relaxations (but possibly with more complexity in RAN2/RAN3?). In any case we are open to productive solution proposals to achieve the WID objectives for dual-parenting in Rel-17 and believe this can be handled in a contribution-driven manner in the WGs. |
| vivo | Agree that intra-carrier DC is good for topology redundancy when multiple carrier for backhauling is not available.  Multiple-MT is not special for intra-carrier DC and should be discussed separately. |
| ZTE | For the topological redundancy discussed in RAN2/3, the main purpose is to achieve load balancing and robustness. We doubt how the intra-carrier DC based topology redundancy could realize the load balance purpose. Since the MCG and SCG share the same carrier, the available radio resource does not increase when IAB node is configured with SCG. Instead, more resource collision may happen which reduce the resource utilization efficiency. That is also the reason why the intra-carrier DC is not supported for UE until now. |
| Ericsson | Our impression of this summary is that it is biased towards the intra-carrier DC camp. That is not the purpose of a moderator’s summary and not the proper procedure in 3GPP.  Furthermore, we question ultimate statements like “if intra-carrier DC cannot be supported in Rel-17, inter-carrier multi-MT won’t be either”. We think it is not fitting for a moderator considering the technical solutions which, in our opinion, are quite different.  Multi-MT allows for independent operation of the parent nodes, similar to inter-carrier DC. We think that is a superior solution that will provide higher performance at the expense of additional IAB HW. From the physical layer perspective, there would be little need for coordination between the parent nodes, since the MTs operate independently. Furthermore, apart from fundamental TDD patterns, no time synchronization requirements need to be set, allowing more flexible deployment of the feature. Also for higher layers, specification is relatively straightforward with no major concerns like the concerns above for intra-carrier DC. |
| Huawei | The purpose of this exercise/email discussion was focused on the required specification effort to support intra-carrier DC. Therefore, it may not be quite relevant to discuss the work on topological redundancy if there is no additional effort.  As to multiple-MT case, we would like to keep it separate, whether or not it will be supported is still controversial in RAN2/3 and the benefit of support this scenario is not quite clear. In Rel-16, the underlying assumption is one IAB node has one MT and one DU even though both can have multiple CCs.  As commented in the first round, the RRM and RF requirements needs to be defined for intra-carrier DC and specification effort should be carefully assessed in RAN4.  In addition, as mentioned above, we believe some discussion are required to check both synchronous or asynchronous intra-carrier DC can be supported and whether the existing UL power control schemes can be reused. This needs some additional effort in RAN1 and RAN4.  Overall, in conclusion, we cannot agree on the moderator summary above and it is clear that we need more work in all the above mentioned WGs if we want to support intra-carrier DC.  In general we also understand that there is no consensus to specify intra-carrier DC for IAB in Rel-17. |
| Intel | We are not sure about intra-carrier multi-MT because intra-carrier multi-MT has not been discussed in RAN1/RAN2 yet. |
| Qualcomm | We agree. |
| Futurewei | We appreciate the constructive approach the moderator takes to analyze the required works for the support of intra-frequency DC. Our understanding is that the extra works in Rel-17 for intra-frequency DC can be reduced by leveraging progresses in intra-band inter-frequency DC and by focusing on the identified use cases (deployment scenarios) requested by operators. |

## Final discussion: Aspects to be handled for intra-carrier DC for IAB

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# Conclusion

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# References

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| [**RP-202533**](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_90e/Docs/RP-202533.zip) | On the support of intra-carrier DC in Rel-17 IAB | Samsung |
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| [**RP-202672**](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_90e/Docs/RP-202672.zip) | Discussion on NR DC operation for IAB | ZTE Corporation |