**3GPP TSG RAN WG1 #103-e R1-200xxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda Item:** **8.10.1**

**Source: Moderator (AT&T)**

**Title: Summary of [103-e-NR-eIAB-01]**

**Document for:** **Discussion/Approval**

# Introduction

This contribution provides a summary of the following email discussion:

[103-e-NR-eIAB-01] Email discussion on enhancements to resource multiplexing between child and parent links of an IAB node – Thomas (AT&T)

* 1st check point: 11/5
* 2nd check point: 11/10
* 3rd check point: 11/12

# Simultaneous Operation of Access and Backhaul Links

**From the eIAB WID:**

* Specification of enhancements to the resource multiplexing between child and parent links of an IAB node, including:
	+ **Support of simultaneous operation (transmission and/or reception) of IAB-node’s child and parent links (i.e., MT Tx/DU Tx, MT Tx/DU Rx, MT Rx/DU Tx, MT Rx/DU Rx)**
	+ Support for dual-connectivity scenarios defined by RAN2/RAN3 in the context of topology redundancy for improved robustness and load balancing.

## Background from RAN1#102-e:

**Agreement**

At least existing Rel-16 bands supporting IAB can be considered when evaluating the feasibility/impact of supporting different multiplexing cases.

**For further discussion in RAN1#102-e**

For different multiplexing cases (cases 1, 2, 3, 4), identify factors that needs to be considered in Rel-17 IAB including:

* Antenna/RF front-end impact
* Interference type and interference handling
* Power control
* Resource partitioning
* Impact on access link UEs
* Where the multiplexing cases are applicable to paired or unpaired spectrum
* Problems due to timing misalignment

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| **Simultaneous operations** |
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## Key requirements/issues for Rel-17 Multiplexing Scenarios

**Goal:**  Identify and describe key requirements and issues for multiplexing scenarios

**Summary of input contributions:**

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| **Huawei (R1-2007594)** | ***Proposal 1:*** *To facilitate simultaneous operations, new IAB node capabilities to indicate the support of restricted simultaneous operations should be introduced* * *The conditions required in the restricted simultaneous operation include at least the requirement for the transmission/reception of IAB-MT.*

***Proposal 2:*** *Simultaneous operations can be implemented in hard resources of IAB-DU only if the transmission or reception of IAB-MT does not impact the operation of IAB-DU.****Proposal 3:*** *For multiplexing Case A and Case B, the following scenarios should be prioritized in Rel-17:** *Multiplexing between parent backhaul link and child backhaul*
* *Multiplexing between backhaul link and access link, and the direction of access link is same with the direction of donor cell*

***Proposal 4:*** *Both DL and UL can be used to implement different resource multiplexing cases.* |
| **Vivo (R1-2007684)** | Proposal 1: Support indication of resources where a certain duplexing operation between backhaul link and access link is adopted. Proposal 2: RAN1 to consider the following options to indicate the resources where simultaneous operation can be operated.* **Option 1: An additional resource type ‘Shared’ is indicated besides H/S/NA.**
* Option 2: Indicate the window for simultaneous operation upon H/S.

Proposal 3: Support FDMed multiplexing between MT and DU. The related signaling is FFS. Proposal 4: When the frequency resources allocated for DU and MT are overlapped, FDMed multiplexing is allowed over non-overlapped part, while SDMed multiplexing is allowed over the overlapped part.. * FFS: The related signaling.
* FFS: H/S/NA properties of the overlapped frequency resource.
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| **CMCC (R1-2008029)** | **Proposal 2:****Both DU working in the NA resources and MT working in the Hard resources should be considered for the simultaneous operation.** **Proposal 3:** **The fall back mechanisms from simultaneous operations to TDM operation should be considered** |
| **Samsung (R1-2008184)** | ***Proposal 1: Hard and soft resource type for IAB-DU can be applicable for multiplexing cases in Rel-17.*** |
| **ZTE, Sanechips (R1-2008858)** | ***Proposal 1: The semi-static resource partitioning scheme similar as Rel-16 mechanism of CU time-domain H/S/NA configuration can be a starting point of resource partitioning scheme in frequency domain.******Proposal 2: For resource configuration in frequency domain for DU, the following types of frequency resources could be configured for each IAB-DU cell:**** ***Hard: The corresponding frequency resource is available for the IAB-DU***
* ***NA: The corresponding frequency resource is not available for the IAB-DU***
* ***FFS: Whether Soft frequency resource should be configured.***

***Proposal 4: For multiplexing Case A/B, study of multi-panel IAB nodes operating in unpaired spectrum should be prioritized in Rel-17.*** |
| **Nokia, Nokia Shanghai Bell (R1-2008863)** | **Proposal 2.1: The S/H/NA resource types are applied with FDM/SDM multiplexing.****Proposal 2.7: For SDM operation, RAN1 shall consider the case of sharing of panels and further investigate the required beam reporting enhancements to enable simultaneous transmission/reception of parent and child links.** **Proposal 2.8: For sharing of antenna panels between MT and DU, consider child node indicating for the parent node the changes of beams or panels used for reception.****Proposal 2.9: For Case A and B, no additional relaxation is supported for using DL resources in uplink transmission (Case A) or using UL resource in DL reception (Case B) by the IAB-MT.**  |
| **Intel (R1-2008995)** | **Proposal 1:** Since an IAB node may only support part of the four simultaneous operations, H/S/NA attributes still need to be provided to TDM MT/DU operation that cannot be simultaneous conducted.  |
| **Lenovo, Motorola Mobility (R1-2009108)** | Proposal 1: Support semi-static resource configuration (partitioning) in time and frequency domains.Proposal 2: Extend hard/soft resource configuration and availability indication to the frequeny domain.Proposal 3: Knowledge of IAB node capability of timing alignment, multi-panel and baseband characteristics may be beneficial from system operation perspective.Proposal 4: Consider mechanisms to identify which IAB node panels are available for its scheduling to facilitate SDM operation between parent IAB node and child IAB node.Proposal 5: Support both downlink and uplink resources for backhaul links and access links. |
| **NTT DOCOMO (R1-2009190)** | Table1: Applicability of Rel-17 multiplexing cases

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| Multiplexing cases | DL/UL slot | Whether applicable to backhaul/access | Potential spec. impact |
| Backhaul? | Access? |
| Case A (MT Tx/DU Tx) | DL slot | Yes | Yes | Case#6 timingMT UL power control |
| UL slot | Yes | No | Case#6 timing |
| Case B (MT Rx/DU Rx) | DL slot | Yes | No | Case#7 timingMT UL power control |
| UL slot | Yes | No | Case#7 timing |
| Case C (MT Rx/DU Tx) | DL slot | Yes | Yes | / |
| UL slot | Yes | No | / |
| Case D (MT Tx/DU Rx) | DL slot | Yes | No | MT UL power control |
| UL slot | Yes | Yes  | / |

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| **ETRI (R1-2009220)** | ***Proposal 1:*** For MT-TX/DU-RX and MT-RX/DU-TX in paired spectrum, we propose considering the configuration of an IAB node in which the opposite directions of the parent and child nodes use the same frequency bands and discussing relevant specification impacts.***Proposal 2:*** We propose studying the support of MT-TX/DU-TX and MT-RX/DU-RX with fully-overlapping frequency band and the feasibility and specification impact including necessary interference management mechanisms and new timing adjustment mechanisms.***Proposal 3:*** It is proposed that the resource multiplexing configurations other than “MT-TX/DU-RX and MT-RX/DU-TX in unpaired spectrum” be considered as higher priority. |
| **CEWiT, IITM, Tejas Networks, Reliance Jio, Saankhya Labs, IITH (R1-2009221)** | **Proposal 1:** IAB node signals its multiplexing capability and supported modes to CU and parent-DU**Proposal 2:** IAB node and its parent node should be made aware of the active mode of operation of the IAB node |
| **Qualcomm (R1-2009269)** | **Proposal 3.1:** **RAN1 should not deprioritize the multiplexing case C (MT RX, DU TX) and case D (MT TX, DU RX) included in the Rel-17 WID and should strive to support them with the minimum required enhancements.** |
| **Ericsson (R1-2009301)** | Proposal 1 Simultaneous transmission based on FDM/SDM principles, i.e., half-duplex transmission, and simultaneous reception based on FDM/SDM principles, i.e., half-duplex reception, are technically feasible and should be RAN 1’s priority in Rel-17.Proposal 2 Simultaneous MT RX and DU TX, i.e., downstream full-duplex, and simultaneous MT TX and DU RX, i.e., upstream full-duplex, are not prioritized in Rel-17.Proposal 3 Specify H/S/NA attributes for IAB-DU frequency-domain resources, using the Rel-16 H/S/NA configuration structure as the baseline.Proposal 4 Further study whether and how to restrict IAB-DU from accessing certain space-domain resources (e.g., in terms of link, beam or angle). |

**FL Proposal 2.1.1: The Rel-16 IAB-DU resource types (Soft/Hard/NA) are the starting point for supporting resource multiplexing for simultaneous operation cases in Rel-17**

* **FFS: Introduction of a new “Shared” resource type**
* **FFS: Extension of resource type definition to frequency domain resources**
* **FFS: Impact on rules governing cell-specific/semi-static signals and channels at the IAB-DU and/or IAB-MT**

**Discussion: Views on proposal 2.1.1?**

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| **Company**  | **Comments**  |
| **NTT Docomo** | **We support the proposal in general. Regarding to the first bullet, we suggest to clarify that the need of introduction of new “shared” resource type will be discussed and identified first. In our views, new resource type is not necessary. Rel-17 simultaneous operation cased can be supported reusing Rel-16 H/S/NA resource types.** |
| **Qualcomm** | We support the FL proposal.In regard to the FFS points, we agree to the 2nd and 3rd bullet.We don’t think the mechanism of the first bullet is necessary: since both CU and parent nodes are provided with IAB-node’s capability on multiplexing, simultaneous operation cases can be supported with existing Rel-16 IAB-DU resource types by one or more of following approaches:* CU’s proper configuration of overlapping Hard/Soft resources and TDD directions between parent and child nodes.
* parent’s availability indication on IAB-node DU’s soft resources that are overlapping with parent’s scheduling over IAB-node MT.
* IAB-node’s implicit determination on soft resources that are overlapping with parent’s scheduling over IAB-node MT.
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| **ZTE, Sanechips** | We agree with the proposal in principle. And for the first FFS, we share similar views with Docomo and Qualcomm, it is not necessary to introduce a new “shared” resource type since the existing H/S, even NA resources could be used for DU and MT simultaneous operation. |
| **vivo** | We are fine with the proposal Regarding 1st bullet. I think the intention is to ensure IAB node and parent node has common understanding on when the simultaneous operation may occur, thus parent node and IAB node may adjust the scheduling scheme accordingly, e.g., when simultaneous reception is enabled at IAB node, IAB node can use lower MCS for PUSCH transmission to cope with the large interference due to DU/MT reception, so as the parent node, etc. Regarding the timing for a certain simultaneous operation case, it is not reasonable to assume that every H resource or S-IA resource is used for simultaneous operation. To be more flexible, whether to perform simultaneous operation also depends on resource type of parent DU, the load of cells and some other factor like interference… thus only part of H/S-IA resource at the IAB node can be used for simultaneous operation. Based on the discussion, the 1st bullet can be formulated as “FFS: how the IAB node and parent node to be aware of the timing that a certain multiplexing case is applicable”.  |
| **Ericsson** | We are generally in favor of the proposal. However, similar to Qualcomm, we don’t see a need for the *shared* resource type. We support the extension of H/S/NA to the frequency domain but do not think it is necessarily suitable for SDM. For this reason, we would like to see another FFS regarding operation in SDM:**FFS: Resource type definitions and operation in SDM**Furthermore, we think it would be beneficial to also study how FDM (or SDM) resource types will co-exist (or not) with TDM resource types (unless companies agree that it is include in the second FFS):**FFS: FDM/SDM resource type relation to TDM resource types.** |
| **Huawei** | We are fine with the main bullet. We have some comments on the first two sub-bullets.* Sub-bullet 1: H/S/NA are the resource attributes of IAB-DU in Rel-16. Adding a “shared” resource type for both IAB-MT and IAB-DU does not seem to be compatible with Rel-16. In addition, simultaneous operation can be readily supported in the existing IAB-DU resource type framework. In particular, Simultaneous operations can be supported in
	+ Hard resources of IAB-DU only if the transmission or reception of IAB-MT does not impact the operation of IAB-DU.
	+ Soft resources as long as the IAB-DU can determine that the transmission or reception of IAB-MT is not impacted by the operation of IAB-DU

Therefore, the motivation of introducing a new resource type is not clear.* Sub-bullet 2: We are unsure about the direction to extend the IAB-DU resource type to frequency domain.
	+ In Rel-16, an IAB node can have multiple carriers at MT and multiple DU cells. Hence there is already some sort of FDM support between parent link and child link, i.e. on CC level. It is not clear how much additional benefit can be obtained by introducing FDM within one carrier.
	+ The resource efficiency of FDM within one carrier does not seems promising compared to TDM considering that some guard band will required for FDM operation.
	+ It may be difficult for a parent node to indicate the resource availability of a IAB-DU soft resource in frequency domain since it will be dependent on a lot of factors such as actual resource allocation at MT, Tx/Rx power at MT, digital filter implementation at MT etc.
	+ If this is to be supported, both semi-static resource configuration and dynamic resource indication should be considered. The signaling overhead for both semi-static resource configuration (may be less of a concern) and DCI format 2\_5 may become every large with a finer frequency granularity.
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| **Intel** | We agree with the main bullet of the proposal. But for the FFS bullets, we have the following views. Regarding the first bullet/FFS, we share similar views with Docomo/Qualcomm/ZTE/Ericsson that it is not necessary to introduce a new “shared” resource type. Rel-17 simultaneous operation cases can be supported reusing Rel-16 H/S/NA resource types. The parent node is already aware of IAB node’s H/S/NA configuration and multiplexing capability, therefore, the “shared” indication is not needed.  |
| **Nokia/NSB**  | We support the main bullet.  For the first sub-bullet, we share a similar understanding as QC. We do not see any need of having a shared resource as the main bullet itself is saying all resource types are still applicable for IAB nodes with simultaneous operation. When the multiplexing mode saying that IAB node is capable for a given simultaneous operation mode, both CU and parent can consider that aspect on using the resource efficiently.  Last sub-bullet, last meeting also had similar bullet. “FFS: Cell-specific/semi-static signals and channels at the IAB-DU and/or IAB”. We could proceed bit further on agreeing that there is no special handling in SDM/FDM cases as well.  FL Proposal 2.1.1: The Rel-16 IAB-DU resource types (Soft/Hard/NA) are applicable ~~the starting point~~ for supporting resource multiplexing for simultaneous operation cases in Rel-17 * ~~FFS: Introduction of a new “Shared” resource type~~
* FFS: Extension of resource type definition to frequency domain resources
* Similar to Rel-16, cell-specific/semi-static signals and channels of the IAB-DU shall be considered as hard resources.
* FFS: additional impact on rules governing cell-specific/semi-static signals and channels at the IAB-DU and/or IAB-MT
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| Samsung | We are OK with the main bullet because we think the Rel-16 IAB resource configuration can be a starting point for Rel-17. In general, for the sub-bullets, it is better to first identify what is the issue which cannot be addressed by using the Rel-16 mechanisms. If justified and agreed, it can be further discussed what kind of enhancements are needed. |

## FL Proposal 2.1.2: Further consider different applicability restrictions for simultaneous operation multiplexing cases:

## FFS: Whether a given case is only applicable for certain resource types or combinations: e.g. DL access, DL backhaul, UL access, UL backhaul

## FFS: Network (including parent node) awareness of “dynamic” child IAB node capability based on other factors including panel selection, interference, timing, transmit power, etc.

## FFS: Necessary differentiation for paired spectrum vs. unpaired spectrum

## Note: There should not be any impact on legacy UE behavior

**Discussion: Views on proposal 2.1.2?**

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| **Company**  | **Comments**  |
| **NTT Docomo** | **We support the proposal in general. Regarding to the second bullet, we suggest more clarification on “dynamic” capability.**  |
| **Qualcomm** | We agree with the FL proposal 2.1.2. |
| **ZTE, Sanechips** | Agree in principle.For the 2nd FFS , the meaning of ‘dynamic’ is not clear to us, does it mean child node could changes its capability dynamically by itself, or network (including parent node) could changes a IAB node’s operation mode based on the listed factors of the IAB node, that is, such ‘dynamic’ is controlled by NW or IAB itself.For the 3rd FFS, from our point of view, the discussion of unpaired spectrum should be prioritized, and paired spectrum can be discussed later if time permits. |
| **vivo** | For the 1st bullet, resource type is understood as H/S/NA? in the example, it seems TDD UL/DL occasion. It means we need to consider both factor?For the 2nd bullet, the intention is fine, however it is not preferred to use sensitive wording, such as capability. Moreover, as commented to proposal 2.1.1, mutual awareness between parent and child are essential. Thus, we prefer to use sentence like “FFS: NW (including parent node and child node) awareness of the timing when a certain multiplexing cases is applicable at child node”.  |
| **Ericsson** | We agree with the proposal and would also like to see the matter of **full duplex vs half-duplex** to be included here. We think it is important that we address the fundamental issues before we continue with the specification work since this agreement will greatly affect, e.g., timing, interference and power control treated in the 2nd IAB AI. |
| **Huawei** | We are fine with main bullet* Sub-bullet 1: Our view is that resource combination for simultaneous operations should NOT be restricted. Whether a specific combination is used or not should be an implementation choice of donor and parent nodes based on the potential interference, IAB node capabilities and scheduling decisions. However, the note is important to keep in mind that the legacy UE behavior should not be impacted.
* Sub-bullet 2: Our view is that an IAB node may be able to support a specific multiplexing case only when some conditions are met. These conditions may include both “semi-static” IAB node capabilities and “dynamic” conditions. Hence we propose to remove “dynamic” for now and focus on the factors required for simultaneous operation.
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| **Intel** | We agree with the FL proposal 2.1.2. |
| **Nokia/NSB**  | We are fine with the direction of the proposal.  Second sub-bullet is creating confusion due to the use of IAB node capability. We suggest the following wording,  FL Proposal 2.1.2: Further consider different applicability restrictions for simultaneous operation multiplexing cases: * FFS: Whether a given case is only applicable for certain resource types or combinations: e.g. DL access, DL backhaul, UL access, UL backhaul
* FFS: Network (including parent node) awareness of ~~“dynamic”~~ child IAB node’s ~~capability~~ ability to support simultaneous operation due to the frequent changes ~~based~~ on ~~other~~ factors including panel selection, interference, timing, transmit power, etc.
* FFS: Necessary differentiation for paired spectrum vs. unpaired spectrum

Note: There should not be any impact on legacy UE behavior  |
| Samsung | We are OK with the main bullet. But, it should be clarified which multiplexing cases are supported in Rel-17. And then, we can further discuss the details for the multiplexing cases. |

## Solutions/enhancements for Rel-17 Multiplexing Scenarios

**Goal:**Summarize proposed new features and enhancements to existing Rel-16 resource allocation functionality (e.g. semi-static resource coordination, DCI Format 2\_5 enhancements, prioritization rules, guard symbols etc.) as a starting point for future discussion

**Summary of input contributions:**

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| **Huawei (R1-2007594)** | ***Proposal 5:*** *If an IAB-MT is additionally provided TDD-UL-DL-ConfigDedicated-IAB-MT, the parameter tdd-UL-DL-ConfigurationDedicated-IAB-MT overrides all symbols per slot over the number of slots as provided by tdd-UL-DL-ConfigurationCommon.****Proposal 6:*** *To increase the resources for simultaneous operation, the specification should allow the collision between tdd-UL-DL-ConfigurationDedicated-IAB-MT and cell-specific signals/channels. In the slots with the collision, the IAB node should ignore tdd-UL-DL-ConfigurationDedicated-IAB-MT. The list of cell-specific signals/channels includes:** *SS/PBCH block*
* *CORESET for Type0-PDCCH CSS set*
* *PRACH*

***Proposal 7:*** *Donor CU can provide two sets of resource configurations to each DU cell: a basic resource configuration for access UEs and one additional resource configuration for child IAB node MTs, and the DU cell should maintain two sets of DU resource configurations simultaneously.* |
| **Vivo (R1-2007684)** | Proposal 5: If different timing modes are supported in TDMed manner for an IAB node, additional guard symbol types should be defined, e.g., * The transition between Case #1 timing mode and Case #6 timing mode.
* The transition between Case #1 timing mode and Case #7 timing mode.
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| **CMCC (R1-2008029)** | **Proposal 4:** **The symbols of an IAB node MT that are configured to transmit or receive SS/PBCH block, PRACH, and CORESET for Type0-PDCCH CSS set should not be overridden by the slot format provided by the additional TDD-UL-DL-ConfigDedicated-IAB-MT.** |
| **Samsung (R1-208184)** | ***Proposal 2: In a collision between cell-specific channels/signals by tdd-UL-DL-ConfigurationCommon and OFDM symbols by tdd-UL-DL-ConfigurationDedicated-IAB-MT, the cell-specific channels/signals have a priority for IAB MT operation.*** |
| **AT&T (R1-2008312)** | **Proposal 2: Specify support for mechanisms to enable non-TDM cell-specific configurations (e.g. STC/SMTC, RACH, system information, periodic CSI-RS etc.) in resources which are not used for access UE transmissions, including overlapping hard and soft configured IAB-DU resources.****Proposal 3: Consider mechanisms to enable dynamic indication of multiplexing capability for a given backhaul link via potential enhancements to existing MAC CE or DCI Format 2\_5 signalling.**  |
| **LG (R1-2008406)** | ***Proposal 2:*** IAB-MT and IAB-DU can determine the time resource simultaneous operation is capable based on transmission-direction combination of IAB-MT and IAB-DU.***Proposal 3:*** Discuss whether simultaneous operation in IAB-DU flexible resource is available or not. ***Proposal 4:*** Discuss how to avoid inter-operator interference with less specification impact in terms of resource configuration***.******Proposal 6:*** For supporting frequency domain multiplexing between MT and DU, frequency-domain configuration should be discussed. * Time domain configuration method (i.e., H/S/NA) defined in Rel-16 IAB can be a starting point of discussion.
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| **ZTE, Sanechips (R1-2008858)** | ***Proposal 3: A frequency resource is equivalent to being configured as hard if it is used to transmit or receive cell-specific/semi-static signals and channels in the frequency resource by DU.*** |
| **Nokia, Nokia Shanghai Bell (R1-2008863)** | **Proposal 2.2: For all multiplexing modes, cell-specific/semi-static signals and channels of the IAB-DU shall be considered as hard resources (like in Rel-16). The parent may be required to know these cell-specific signals and channels only when IAB node has a certain restriction on supporting the multiplexing mode due to cell-specific/semi-static signal and channels.****Proposal 2.3: For FDM operation of the IAB node, the availability of PRBs in hard symbols shall be additionally indicated via semi-static CU signaling.** **Proposal 2.4: For FDM operation, a dynamic indication of frequency availability of soft resources shall be controlled by the parent via introducing frequency availability indication.** **Proposal 2.5: For SDM operation, a dynamic indication of spatial restrictions (or availability) of soft resources shall be further studied to enable efficient SDM operation at the IAB node.** **Proposal 2.6: For FDM/SDM operation, allowed direction of the transmission for the IAB DU in F-S resources may be further controlled by the parent node by using a dynamic indication.**  |
| **Intel (R1-2008995)** | **Proposal 2:** H/S/NA DU resources colliding with simultaneous operations can be fulfilled by existing Rel-16 resource configuration mechanism with behaviour enhancements. No additional signalling is needed. * For H/S-IA DU resources, new behaviors are added as:
* MT can transmit or receive cell specific signals/channels concurrently to DU’s transmission or reception without being given priority when simultaneous operation allows.
* Parent DU can further schedule DL or UL transmission on the H/S-IA DU resources when simultaneous operation allows.
* For NA/S-INA DU resources, new behaviors are added as:
	+ DU can schedule DL or UL transmission on the NA/S-INA DU resources when simultaneous operation allows.

**Proposal 3:** For simultaneous operations in FDM, both semi-static frequency-domain resource configuration (new F1AP signalling) and dynamic frequency-domain resource indication (extend to DCI format 2\_5 or a new DCI format) for an IAB DU are needed. **Proposal 11:** Add reference SCSs for soft resource availability indication configuration in the RRC IE *AvailabilityCombinationPerCell*. * For unpaired spectrum operation, a reference SCS configuration $µ\_{AI}$ is provided by *subcarrierSpacing-AI* and, when a supplementary UL carrier is configured for the serving cell, a reference SCS configuration $µ\_{AI,SUL}$ is provided by *subcarrierSpacing2-AI* for the supplementary UL carrier.
* For paired spectrum operation, a reference SCS configuration $µ\_{AI,DL}$ for a DL BWP is provided by *subcarrierSpacing-AI* and a reference SCS configuration $µ\_{AI,UL}$ is provided for an UL BWP by *subcarrierSpacing2-AI*.

**Proposal 12:** For DCI format 2\_5 operation in paired spectrum with a reference SCS configuration $µ\_{AI,DL}$ provided for the reference DL BWP of the serving cell and a reference SCS configuration $µ\_{AI,UL}$ provided for the reference UL BWP of the serving cell: * If $µ\_{AI,DL}\geq µ\_{AI,UL}$: for each $2^{(µ\_{AI,DL}-µ\_{AI,UL})}+1$ values provided by *resourceAvailability*, the first $2^{(µ\_{AI,DL}-µ\_{AI,UL})}$ values for the combination of availability indication values are applicable to the reference DL BWP and the next value is applicable to the reference UL BWP.
* If $µ\_{AI,DL}<µ\_{AI,UL}$: for each $2^{(µ\_{AI,UL}-µ\_{AI,DL})}+1$ values provided by *resourceAvailability*, the first value for the combination of availability indication values are applicable to the reference DL BWP and the next $2^{(µ\_{AI,DL}-µ\_{AI,UL})}$ values are applicable to the reference UL BWP.
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| **NTT DOCOMO (R1-2009190)** | **Proposal1:** **Based on the Rel-16 signaling, IAB node MT and DU can simultaneously perform Tx and/or Rx on DU hard/soft/NA symbols and following new IAB node behavior should be defined.*** **On a DU hard/soft-IA symbol, DU can perform either Tx or Rx, and MT can also perform either Tx or Rx on the symbol if multiplexing capability of the transmission/reception direction combination of MT and DU is reported by IAB node.**
* **On a DU NA/soft-INA symbol, MT can perform either Tx or Rx, and DU can also perform either Tx or Rx on the symbol if multiplexing capability of the transmission/reception direction combination of MT and DU is reported by IAB node.**

**Proposal2: On a DU hard/soft-IA flexible symbol, parent node can configure/indicate/schedule IAB node MT Tx or Rx on the symbol, and IAB node DU will perform either Tx or Rx on the symbol based on MT transmission/reception direction and its multiplexing capability.****Proposal4: Both semi-static configuration and dynamic indication of frequency resource availability for IAB node DU should be considered to support FDM resource multiplexing.****Proposal5: For the configuration and indication of IAB-DU frequency resource availability for FDM resource multiplexing, following methods can be considered.*** **Option1: For each frequency resource of DU, hard/soft/NA resource types can be configured separately from the configuration for time resource. For a DU frequency resource configured as soft, availability of the frequency resource can be dynamically indicated.**
* **Option2: For each time-frequency resource DU, hard/soft/NA resource types can be configured jointly. For a resource configured as soft, availability of the resource can be dynamically indicated.**

**Proposal7: Whether different value range of the number of guard symbols is needed for the new timing modes need to be studied.****Proposal8: Further study whether to support dynamic switching among different timing modes and the potential enhancement on multiple indications of guard symbols for different timing modes if supported.** |
| **CEWiT, IITM, Tejas Networks, Reliance Jio, Saankhya Labs, IITH (R1-2009221)** | **Proposal 3:** CU signals H/S/NA to IAB nodes based on active mode of operation**Proposal 4:** IAB node use IA signalled by parent in DCI format 2\_5 for S resource based on active mode of operation |
| **Qualcomm (R1-2009269)** | **Proposal 4.1:** **Extend the enhanced multiplexing capability indication to support local refinement indication (i.e.** **whether the capability is available to what degree under which conditions) to the parent-node (e.g. via MAC-CE).****Proposal 5.1:** **Extend the Rel-16 semi-static DU resource management to frequency-domain, e.g. CU provides a mask in frequency to coordinate frequency-domain resources between IAB-DUs.****Proposal 5.2:** **Extend the Rel-16 semi-static DU resource management to spatial-domain as follows:**1. **Support indicating the configuration(s) required to enable an enhanced multiplexing capability by IAB-node DU to donor CU, e.g. for which beams (SSBs) or which served child-nodes, the IAB-node can operate in the enhanced multiplexing mode.**
2. **Support indicating DU resource type (Hard/Soft/NA) per beam or per SSB area by donor CU to an IAB-node DU.**
 |
| **Ericsson (R1-2009301)** | **Proposal 6 A frequency-domain DU resource assigned to cell-specific/semi-static signals/channels, such as SSB transmission, PRACH reception, periodic CSI-RS transmission, PDCCH transmission for Type0-PDCCH CSS sets and SR reception, is always treated as if it were configured as a Hard DU resource.****Proposal 7 Dedicated transmission directions in terms of DL/UL for cell-specific signals/channels should be maintained when configuring simultaneous operation at an IAB-node.****Proposal 8 It is FFS of how to specify IAB-MT’s behavior if symbols 1) for SSB reception are configured as UL; 2) for PRACH transmission are configured as DL; 3) for CORESET for Type0-PDCCH CSS set reception are configured as UL.****Proposal 9 The parent node is dynamically provided with changes of the IAB-node’s multiplexing-capability.** |

**FL Proposal 2.2.2: The following categories of enhancements should be further considered to support simultaneous operation of access and backhaul links (not an exhaustive list):**

* **Enhancements to the semi-static IAB-DU resource configuration**
	+ **Examples include support for frequency domain partitioning, partitioning of TDM/non-TDM resources, and multiple active resource configurations**
* **Enhancements to the semi-static IAB-MT resource configuration**
	+ **Examples include overriding additional symbols of the dedicated and common TDD UL/DL configurations**
* **Enhancements to support the dynamic indication of available resources to support SDM/FDM of access and backhaul links**
	+ **Examples include dynamic indication of availability based on multiplexing type or capability**
* **Enhancements to the rules governing collisions of Hard/NA resources of the DU with cell-specific/semi-statically configured signals and channels at the IAB-DU and/or IAB-MT**
* **Enhancements to inter-IAB signaling**
	+ **Examples include reporting of parent’s multiplexing capability, guard symbol configurations, early TCI indication**
* **Enhancements to guard symbol indication/allocation**
	+ **Enhancements include new guard symbol allocations to support Case #6/Case #7 timing mode**
* **Enhancements to support use of DCI Format 2\_5 in paired spectrum**

**Discussion: Views on proposal 2.2.2?**

|  |  |
| --- | --- |
| **Company**  | **Comments**  |
| **NTT Docomo** | **We support the proposal in general. But we suggest to clarify that the need of each of the above enhancements will be discussed and identified first.** |
| **Qualcomm** | We generally agree to the proposal. It may help the discussion if some focus / prioritization could be establish among all the listed items (perhaps based on actual need, as NTT Docomo indicated). |
| **ZTE, Sanechips** | Agree in principle, given the time is limited for Rel-17, it is better to perform prioritization among the listed items, and we also prefer to add a general principle here, that is all the solutions of the listed items should not impact access UE’s performance/behavior. |
| **vivo** | Generally fine, however it is suggested to capture orthogonal discussion between proposals. The resource type discussion has been captured in proposal 2.1.1, which should be removed from the subbullets.  |
| **Ericsson** | We support the proposal in general but agree with both DOCOMO and Qualcomm that any enhancement should address a specific need. |
| **Huawei** | We are fine with the main bullet. Some of the sublets are not quite clear to us hence some further discussion will be required. We also agree with other companies the each enhancement should be justified with the need. |
| **Intel** | We partially agree with the proposal.For the 4th bullet, we think the collision rules have already been defined in Rel-16 IAB. The additional collision rule we need to discuss here should be the following: * **Enhancements to the rules governing collisions of Hard/S-IA or NA/S-INA DU resources with simultaneous operations at the IAB node**
 |
| **Nokia/NSB**  | We are fine with the direction of the proposal. However, several comments as below.   We would like to also discuss reporting enhancements for IAB node such that simultaneous operation can be supported. Please see the added text.   On semi-static channels, it is not clear why would we change the behavior from Rel-16. Suggest making it conditional as Rel-16 behaviors are defined to enable system performance not to get impacted.   Also, there is mentioning of “TCI indication’ with inter-IAB coordination. This is not fully clear.   Last sub-bullet, we do not think that is essential, but anyways, no objections as everything is still for further study.   FL Proposal 2.2.2: The following categories of enhancements should be further considered to support simultaneous operation of access and backhaul links (not an exhaustive list): * Enhancements to the semi-static IAB-DU resource configuration
* Examples include support for frequency domain partitioning, partitioning of TDM/non-TDM resources, and multiple active resource configurations
* Enhancements to the semi-static IAB-MT resource configuration
* Examples include overriding additional symbols of the dedicated and common TDD UL/DL configurations
* Enhancements to support the dynamic indication of available resources to support SDM/FDM of access and backhaul links
* Examples include dynamic indication of availability based on multiplexing type or capability
* Enhancements to support the reporting of restrictions associated when supporting SDM/FDM of access and backhaul links
* Examples include dynamic reporting of beams can be used by the IAB MT when supporting SDM operation
* Additional enhancements to the rules governing collisions of Hard/NA resources of the DU with cell-specific/semi-statically configured signals and channels at the IAB-DU and/or IAB-MT
* Enhancements to inter-IAB signaling
* Examples include reporting of parent’s multiplexing capability, guard symbol configurations~~, early TCI indication~~
* Enhancements to guard symbol indication/allocation
* Enhancements include new guard symbol allocations to support Case #6/Case #7 timing mode
* Enhancements to support use of DCI Format 2\_5 in paired spectrum

   |
| Samsung | We are fine with the main bullet. But, it should be clarified what the issue is. If justified and agreed, it can be further discussed what kind of enhancements are needed. |

# Resource allocation for dual-connectivity scenarios (i.e. IAB-MT with concurrent BH links with two parent nodes)

**From the eIAB WID:**

* Specification of enhancements to the resource multiplexing between child and parent links of an IAB node, including:
	+ Support of simultaneous operation (transmission and/or reception) of IAB-node’s child and parent links (i.e., MT Tx/DU Tx, MT Tx/DU Rx, MT Rx/DU Tx, MT Rx/DU Rx)
	+ **Support for dual-connectivity scenarios defined by RAN2/RAN3 in the context of topology redundancy for improved robustness and load balancing.**

## Background from RAN1#102-e:

**Conclusion**

At least the inter-carrier DC scenario can be considered in Rel-17. Further discussion in RAN3/RAN Plenary may be necessary for the intra-carrier DC scenario.

**Agreement**

Reuse by IAB-MT of existing Inter-frequency DC is considered as a starting point to support concurrent BH links to two parents.

* FFS: Reuse of multi-TRP transmission resource allocation features (if intra-freq DC scenario is supported for IAB)
* FFS: Additional specification effort to support IAB

**For companies to further consider:**

The following categories of enhancements have been proposed to support DC scenarios (not an exhaustive list):

* Inter-parent DU resource coordination mechanisms and signaling
* Resource allocation/scheduling conflict resolution rules at the parent or child node
* Per-link IAB-DU resource configurations at the parent node

## Key requirements/issues for Dual Connectivity Scenarios:

**Goal:**Identify and describe key requirements and issues for multi-parent scenarios

**Summary of input contributions:**

|  |  |
| --- | --- |
| **Vivo (R1-2007684)** | **Proposal 6: RAN1 supports both intra-carrier DC and inter-carrier DC.** **Proposal 7: RAN1 to handle the scheduling conflict (i.e., UL and DL conflict on a given time instant) between cells of MT MCG and SCG.*** **For inter-carrier DC, reuse the rules specified in Rel-16 TEI to address UL/DL conflict at a given time. FFS extension to intra-carrier DC.**
* **FFS: Inter-CU exchange of parent nodes’ resource configurations, in case that parent nodes corresponding to MCG and SCG belong to different CUs. Related signaling up to RAN3.**

Proposal 8: RAN1 to handle the DU resource type indication conflict in inter-carrier and intra-carrier DC case. * **FFS: Inter-CU exchange of resource type configuration of a given IAB DU, in case that its parent nodes belong to different CUs. Related signaling up to RAN3.**
* **FFS: MT behavior when receiving different dynamic resource type indication (e.g., resource availability indication) from MCG and SCG.**
 |
| **CMCC (R1-2008029)** | **Proposal 1:****A conflict rule should be considered for IAB when the two parent node provide conflicted indications or scheduling.** |
| **Samsung (R1-2008184)** | ***Proposal 3: Focus on the inter-carrier DC scenario in RAN1#103-e.******Proposal 4: As a baseline, consider dual connectivity scenarios with two parent nodes under same IAB-donor in Rel-17.******Proposal 5: Discuss whether or not separate signaling between IAB MT and different parent IABs are necessary in Rel-17.******Proposal 6: Discuss how to address scheduling collision issues for child IAB between MCG and SCG.*** |
| **LG (R1-2008406)** | ***Proposal 7:*** Inter-band DC is supported only for Rel-17 eIAB. |
| **Nokia, Nokia Shanghai Bell (R1-2008863)** | **Proposal 3.1: RAN1 to make an assessment about the required specification impacts for the decision of whether intra-frequency DC would be feasible within the Rel.17 timeframe.** |
| **Intel (R1-2008995)** | **Proposal 7:** For enabling dual-connectivity in IAB,only inter-carrier DC is supported inRel-17. |
| **Qualcomm (R1-2009269)** | **Proposal 2.1:****In Rel-17, the scope of supporting multi-parent for IAB shall include the following:** 1. **Support of inter-band NR-DC between FR2 bands**
2. **Support of intra-band NR-DC between different carries within a FR2 band.**
3. **Multi-parents can be intra-donor or inter-donor.**
4. **FFS: support of intra-frequency NR-DC.**
 |
| **Ericsson (R1-2009301)** | **Proposal 10 Intra-carrier DC is not further studied for Rel-17 enhanced IAB.** |

**FL Proposal 3.1.1: Consider both intra-donor and inter-donor multi-parent operation in Rel-17**

**Discussion: Do you support proposal 3.1.1?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **NTT Docomo** | **Yes** |  |
| **Qualcomm** | Yes. | None. |
| **ZTE, Sanechips** | Yes | But from RAN1’s perspective, a unified scheme for both scenarios is preferred. |
| **vivo** | Yes |  |
| **Ericsson** | Conditional yes | Inter-donor operation will be substantially more complicated if intra-carrier DC is supported, in which case we do not support inter-donor operation. |
| **Huawei** | Not sure | Probably this can be decided by RAN2. |
| **Intel** | Partially  | Not sure about whether inter-donor operation is required in Rel-17.  |
| **Nokia/NSB**  | Yes  | We further like to discuss on use case scenarios and simply the required enhancements by common framework.    |
| Samsung | Yes for intra-donor  | Regarding intra-donor, we are fine to consider it in Rel-17. But, regarding inter-donor, we need inputs from RAN2/RAN3. |

**FL Proposal 3.1.2: Discuss the required specification impacts of supporting the following for IAB in Rel-17:**

* **Inter-carrier, inter-band NR-DC**
* **Inter-carrier, intra-band NR-DC**
* **Intra-carrier NR-DC**

**Note: RAN1 will decide in RAN1#103-e about whether intra-band/intra-carrier scenarios are supported in addition to inter-carrier, inter-band scenarios in Rel-17**

**Discussion: Views on proposal 3.1.2?**

|  |  |
| --- | --- |
| **Company**  | **Comments**  |
| **NTT Docomo** | **We are fine to discuss the required specification impacts of each scenario.** |
| **Qualcomm** | We agree with the proposal. We think the inter-carrier, intra-band NR-DC for FR2 should be the highest priority for RAN1. |
| **ZTE, Sanechips** | We are OK to discuss this, but we suggest to also clarify the benefit and necessity to support intra-band/intra-carrier DC, and to see whether it is deserved. |
| **vivo** | Fine to discuss the spec. impact for each scenario. |
| **Ericsson** | We do not agree that intra-carrier DC is part of the WI since it neither includes multiplexing between a parent and child node, nor is it a defined DC mode.However, we think that most companies have realized the technical issues with intra-carrier DC and that we therefore are ready for a more far reaching proposal:**Proposal: Inter-carrier DC is supported for both inter-band and intra-band operation.** |
| **Huawei** | We are fine with the proposal from Ericsson.  |
| **Intel** | We agree with Ericsson’s proposal.  |
| **Nokia/NSB**  | Use of wording “NR-DC” could be avoided by simplifying IAB discussion mainly focused on inter carrier multi parent or intra-carrier multi-parent scenarios. With that approach, we avoid contradicting terminologies.   |
| Samsung | We fine to discuss inter-carrier NR-DC. But, regarding intra-carrier NR-DC, we need RAN plenary guidance whether or not it is considered in Rel-17. Until the input from RAN plenary is received, RAN1 should focus on inter-carrier NR-DC.  |

**FL Proposal 3.1.3: Consider how to address scheduling collisions and resource indication conflicts between multiple parent nodes**

**Discussion: Do you support proposal 3.1.3?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **NTT Docomo** | **Yes** |  |
| **Qualcomm** | Yes. | None. |
| **ZTE, Sanechips** |  | This is related to FL proposal 3.1.2, if only inter-band DC is supported, such collisions may be not a issue. |
| **vivo** | Yes |  |
| **Ericsson** | Yes | If intra-carrier DC is excluded, this will essentially boil down to TDD pattern synchronization |
| **Huawei** | Yes | If 3.1.2 is agreed, the collisions should be handled between multiple parent nodes. |
| **Intel** | Yes |  |
| **Nokia**  | Yes  | As we use multiple parent nodes, it is good that we use multiple parents in other agreements as well.   |
| Samsung | Yes | We are OK with the proposal taking into account scheduling decision is independently performed per MCG and SCG.  |

## Solutions/enhancements for Dual Connectivity Scenarios:

**Goal:**  Summarize proposed new features and enhancements to existing Rel-16 resource allocation functionality (e.g. semi-static resource coordination, DCI Format 2\_5 enhancements, prioritization rules, guard symbols etc.) as a starting point for future discussion

**Summary of input contributions:**

|  |  |
| --- | --- |
| **AT&T (R1-2008312)** | **Proposal 1: Per-link IAB-DU resource configurations and signaling between multiple IAB-nodes/donors should be supported in Rel-17.** |
| **Nokia, Nokia Shanghai Bell (R1-2008863)** | **Proposal 3.2: IAB-MT shall support both single DCI based and multi-DCI based multi-TRP transmission schemes.****Proposal 3.3: For multi-DCI based multi-TRP reception supported IAB node, the explicit indication of a soft resource is determined based on indications received from both TRPs, and a soft resource is available only when IAB-MT receives DCI 2-5 indications allowing the use of the soft resource.** |
| **Intel (R1-2008995)** | **Proposal 8:** Further discussion on DCI format 2\_5 handling for IAB dual-connectivity scenarios is needed. **Proposal 10:** For the semi-static DU resource configurations, additionally support per-link configuration.  |
| **NTT DOCOMO (R1-2009190)** | **Proposal6: To support TDM resource multiplexing in DC scenario, following methods can be considered:*** **Option1: Rel-16 mechanism of DU H/S/NA resource configuration is reused. DU can Tx/Rx on a symbol configured as hard, or a symbol configured as soft and indicated as available by both parent nodes.**
* **Option2: DU H/S/NA resource types are configured per DU serving cell and per parent node. DU can Tx/Rx on a symbol configured as hard for both parent nodes, or a symbol configured as hard for one parent node while configured and indicated as soft-IA by the other parent node, or a symbol configured and indicated as soft-IA by both parent nodes.**
 |
| **Lenovo, Motorola Mobility (R1-2009108)** | Proposal 7: Define signaling for IAB nodes in the DC mode to inform parent IAB nodes of the status of availability of soft resources. |
|  |  |
|  |  |

**FL Proposal 3.2.1: Per-link IAB-DU resource configurations from the donor CU to the parent nodes should be supported in Rel-17**

 **FFS: Additional signaling from child IAB-MT to parent nodes or between parent nodes**

**Discussion: Do you support proposal 3.2.1?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **Qualcomm** | Yes. | None. |
| **ZTE, Sanechips** | No | Such configuration is not necessary for inter-band DC cases, the supported DC scenarios should be determined first before we agree on this.  |
| **Ericsson** | No | We don’t see a need for this functionality in inter-carrier DC. Furthermore, it is not an urgent decision to be made. |
| **Huawei**  | No | We think it will be good first clarify why per-link resource configuration is required and to which cases it should be applied. It is probably too early to take the agreement |
| **Intel** | Yes | We support per-link resource configuration for the following reasons: * When an IAB MT is connected to multiple parent DUs, link-specific resource configuration can differentiate the IAB MT with dual-connectivity from other IAB MTs and coordinate resource configurations between the IAB MT’s multiple parent DUs.
* Per-link DU resource configuration has additional benefit in interference management (for example, by setting NA resource in a specific link) of adjacent links with different parent DUs.
* Furthermore, the D/U/F/H/S/NA configuration for each child IAB DU can be different depending on its own semi-static child DU resource configuration, which makes the resource available for each child IAB MT different from each other. The per-link resource configuration at an IAB DU can be more flexible to satisfy the different resource availability of each child IAB MT.
 |
| **Nokia**  | Yes  | This was already discussed heavily in Rel-16 and believed necessary.   |
| Samsung | No | We have similar understanding with other companies regarding urgency of the issue. |

**FL Proposal 3.2.2: Consider extensions for both single DCI based and multi-DCI based multi-TRP transmission schemes at the IAB-MT to support explicit indication of soft resources by DCI Format 2\_5.**

**Discussion: Do you support proposal 3.2.2?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **NTT Docomo** | **Yes in general.** | **We suggest more clarification on “single DCI based” and “multi-DCI based”. Does multi-DCI based mean each parent node indicate soft resource availability independently?****Does single-DCI based mean one parent node indicate soft resource availability and the indication applies for both parent nodes?** |
| **Qualcomm** | No. | We have concerns on the wording of the proposal, especially on use of the term “multi-TRP” in support of multi-parent in IAB. The explicit availability indications from multi-parents shall be considered under NR-DC framework, not under Multi-TRP framework where a single MAC scheduler is assumed among multi-TRPs.  |
| **ZTE, Sanechips** | No | Share similar view with Qualcomm, according to the objective of the WI, supporting of IAB multi-parents should be discussed under the dual-connectivity scenarios defined by RAN2/RAN3. |
| **vivo** | Not clear | Do you mean one resource availability indication can target multiple DU cells. The motivation is not so clear for us. |
| **Ericsson** | No | Multi-TRP is not included as enhancements to dual connectivity. This would be an extension of the WI that we don’t agree to. |
| **Huawei** | No | It is a bit too early to have this agreement given that we have not agreed that MTRP transmission should be supported for IAB. |
| **Intel** | No | Share similar view with Qualcomm/ZTE/Ericsson/Huawei.  |
| **Nokia**  | Yes  | IAB MT can already support UE features and multi-TRP is one of them. When multi-DCI is supported, DCI 2-5 could come from both TRPs, and conflicting indications may be received by the IAB MT. This has to be resolved whether as Rel-16 CR or Rel-17 enhancement.   |
| Samsung | No | Not sure why multi-TRP schemes are considered here. |