**3GPP TSG RAN WG1 #104-e R1-210xxxx**

**e-Meeting, January 25th – February 5th, 2021**

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

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

**Title: Summary of [104-e-NR-eIAB-01] – 2nd Checkpoint**

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

# Introduction

This contribution provides a summary of the following email discussion:

[104-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: Jan 27
* 2nd check point: Feb 1
* 3rd check point: Feb 5

# 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.

**Summary of input contributions:**

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| **Huawei (R1-2100219, R1-2100221)** | ***Proposal 1:*** *To facilitate simultaneous operation multiplexing cases, at least the following restrictions for the transmission/reception of IAB-MT should be aware by the parent node* * *Multiplexing case A (Simultaneous MT-Tx/DU-Tx): Case#6 timing, Enhanced power control scheme*
* *Multiplexing case B (Simultaneous MT-Rx/DU-Rx): DMRS ports orthogonalization*
* *Multiplexing case C (Simultaneous MT-Rx/DU-Tx): DMRS ports orthogonalization*
* *Multiplexing case D (Simultaneous MT-Tx/DU-Rx): Enhanced power control scheme, DMRS ports orthogonalization*

***Proposal 2:*** *To extend the applicability of FDM, an IAB node can report the desired guard band for each {MT CC, DU cell}-pair for FDM operation.****Proposal 3:*** *Inter-CC multiplexing between IAB-MT and IAB-DU should be the baseline for FDM.****Proposal 4:*** *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 5:*** *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 6:*** *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.****Proposal 1:*** *Number of guard symbols for MT and DU flexible symbols = min(Number of guard symbols for MT and DU downlink switching, Number of guard symbols for MT and DU uplink switching)****Proposal 2****: Introduce negative value of Ng to support efficient resource utilization.* |
| **Vivo (R1-2100463)** | **Proposal 1: Support indication of time-frequency resources where a certain duplexing operation between backhaul link and child/access link is adopted.**Proposal 2: Additional signaling, e.g., dynamic and/or semi-static signaling, should be defined to indicate the timing of a given duplexing mode of an IAB node. Proposal 3: RAN1 to support operational frequency resource configuration for DU. Proposal 4: The frequency resource types of H/S/NA should be supported. Proposal 5: The dynamic resource availability indication in the frequency domain is added to DCI format 2-5.Proposal 6: 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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| **Intel (R1-2100670)** | **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. **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 semi-static H/S/NA resource type indication for DU frequency-domain resources, several schemes can be considered. * Scheme 1: RB-based H/S/NA indication, i.e., H/S/NA is indicated per DU RB over the whole CC.
* Scheme 2: RIV-based H/S/NA indication, i.e., H/S/NA is indicated per DU RIV (each RIV has its starting point and number of RBs).
* Scheme 3: MT BWP-based H/S/NA indication, i.e., assuming all RBs not overlapping with MT BWPs as Hard, and H/S/NA is indicated per MT BWP.

**Proposal 4:** Further discuss dynamic indication about soft availability in DU frequency-domain, either by extend DCI format 2\_5 or a new DCI format. **Proposal 8:** 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 9:** 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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| **CEWiT, IITM, IITH, Tejas Networks, Reliance Jio (R1-2100690)** | **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**Proposal 3:** IAB node in simultaneous mode of operation interpret the H/S/NA configuration, signalled by the CU, based on active mode of operation**Observation 2:** The usage of NA resource can be minimized to the interference reduction scenarios **Proposal 4:** IAB node use IA signalled by parent node in DCI format 2\_5 for S resource based on active mode of operation**Proposal 5:** CU indicate H/S/NA configurations to frequency domain resource at IAB-DU**Proposal 6:** IAB-DU use S frequency resource for Tx/Rx in child/access link when* Tx/Rx at IAB-DU is not impacting the Tx/Rx IAB-MT
* IAB-MT receive explicit indication from parent-DU indicating the S resource as available for IAB-DU

**Proposal 7:** Mechanism to fall back to TDM mode from simultaneous mode should be supported at IAB node**Observation 3:** Multiplexing capability information of parent might be useful to the IAB node in certain casesProposal 8: Mechanism to inform multiplexing capability of prospective parent nodes to IAB node should be supported |
| **LG (R1-2100717)** | **Simultaneous operation schemes between MT and DU*****Proposal 1:*** IAB-MT and IAB-DU can determine the operating time resource based on DU H/S/NA resource type and transmission-direction combination of IAB-MT and IAB-DU as follows.* DU Hard or Soft with availability indication
	+ DU can perform Tx/Rx
	+ MT can perform Tx/Rx, if multiplexing capability of the Tx/Rx direction combination of MT and DU is no-TDM.
* DU NA or Soft without availability indication
	+ MT can perform Tx/Rx
	+ DU can perform Tx/Rx, if multiplexing capability of the Tx/Rx direction combination of MT and DU is no-TDM.

***Proposal 2:*** Discuss whether simultaneous operation in IAB-DU flexible resource is available or not.***Observation 1:*** DU and MT transmission with high-power on the uplink resource of other operators needs to be avoided.***Proposal 3:*** Discuss how to avoid inter-operator interference with less specification impact in terms of resource configuration.***Proposal 4:*** To support frequency domain multiplexing between MT and DU, H/S/NA resource type in frequency-domain is defined and configured to DU.* Further study configuration granularity for frequency-domain H/S/NA resource type.

***Proposal 5:*** Discuss on DCI format for availability indication of soft resource for frequency domain taking into account specification impact and UE monitoring complexity; * Approach 1: DCI format 2\_5 is utilized for availability indication of soft resource for both frequency domain and time domain.
* Approach 2: New DCI format is introduced for availability indication of soft resource for frequency domain, which is distinguished with legacy DCI format 2\_5.

***Proposal 6:*** If a DU NA or Soft frequency resource is configured for cell-specific signal(s)/channel(s), the resource is treated as if it were a Hard resource.  |
| **AT&T (R1-2100777)** | **Proposal 1: Extend the definition of soft resources to support simultaneous (half and full duplex) operation in Rel-17, keeping the Hard/NA definitions to support TDM-only operation as in Rel-16.****Proposal 2: Specify support for mechanisms to enable non-TDM (half-duplex and full-duplex) 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 and guard symbols for a subset of time/frequency resources of given backhaul link via potential enhancements to existing inter-IAB node signalling.**  |
| **Nokia, Nokia Shanghai Bell (R1-2100833)** | **Proposal 2.1: 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 2.2: For FDM operation of the IAB node, the availability of PRBs in hard symbols of IAB DU shall be additionally indicated via semi-static CU signaling.** **Proposal 2.3: For FDM operation, a dynamic indication of frequency availability of soft resources shall be controlled by the parent via introducing frequency availability indication.** **Proposal 2.4: 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 2.5: 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.** **Proposal 2.6: For coexistence of FDM resources and TDM resources,** * **Frequency availability indications (semi-static and dynamic) for a given resource can be used to determine whether the resource is TDM or FDM resource, and FDM resources can always be used for TDM operation.**

**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.** **Proposal 2.10: Multiplexing enhancements for full-duplex cases are left for implementation.** |
| **ZTE, Sanechips (R1-2100958, R1-2100960)** | [*Proposal 1:* At least to support FDM, the Rel-16 IAB DU resource type definitions needs to be extended to frequency domain resources.](#_Toc384)[*Proposal 2:* For resource configuration in frequency domain for DU, the following types of frequency resources could be configured for each IAB-DU cell:](#_Toc10116)[• Hard: The corresponding frequency resource is available for the IAB-DU](#_Toc12641)[• NA: The corresponding frequency resource is not available for the IAB-DU](#_Toc5756)[• FFS: Whether Soft frequency resource should be configured](#_Toc15309)[*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.](#_Toc30692)[*Proposal 4:* Whether to extend DCI Format 2\_5 to frequency domain resources can be considered after determining whether to introduce soft resources in frequency domain.](#_Toc429)[*Proposal 5:* Support of full-duplex cases (i.e., simultaneous DU-Tx/MT-Rx and simultaneous DU-Rx/MT-Tx) is left to implementation.](#_Toc9108)***Proposal 1：Parent node or donor CU can be made aware of the no-TDM multiplexing capability of an IAB node such as SDM, FDM or SDM and FDM.**** ***FFS: Whether such no-TDM multiplexing capability is separately or jointly reported with transmission-direction combinations.***
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| Lenovo, Motorola Mobility (R1-2100990) | Proposal 1: Define a group of N PRBs as the unit of bandwidth for configuration and signalling. N can be a specified constant or configured by the IAB-CU.Proposal 2: Support semi-static resource configuration in time and frequency domains.Proposal 3: Extend availability indication to the frequency domain.Option 1 (higher flexibility): Extend H/S/NA configurations and availability indication to the frequency domain.Option 2 (better coexistence): Support frequency-domain availability indication on soft symbols.Proposal 4: Support conditional availability indication as a balance between best-effort non-TDM and existing availability indication.Proposal 5: 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. |
| ETRI (R1-2101083) | ***Proposal 1: Introduce a higher-layer parameter to configure IAB-DU resource types in the frequency domain.**** ***Granularity of the configuration should be equal to or smaller than “per cell”***

***Proposal 2: Enhance DCI format 2\_5 to enable frequency domain resource availability indication.**** ***Alt.1: Extend of the mapping between values of resourceAvailability elements and types of soft symbol availability to frequency domain resource availability.***
* ***Alt.2: Introduce a new RNTI to indicate frequency domain resource availability.***

***Proposal 3: Study BD/CCE limits enhancement to allocate more BD/CCE budgets for the cells with simultaneous operations****.* |
| Samsung (R1-2101227) | ***Proposal 1: Further study spec. impacts on an extension of resource type definition to frequency domain resource.******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.******Proposal 3: Hard and soft resource type for IAB-DU can be applicable for multiplexing cases in Rel-17.*** |
| Qualcomm (R1-2101483) | **Observation 3.1:** **For simultaneous operation at an IAB-node between parent and child links, frequency-domain multiplexing (FDM) can provide benefit for interference management. Comparing FDM with TDM,** * **Both require resource overhead to handle timing misalignment between MT and DU, e.g. guard symbols for TDM and guard tones for FDM.**
* **FDM provides advantage of latency over TDM and more flexibility in scheduling in time.**
* **FDM suffers more on power imbalance issue than TDM, which may require more guard tones in-between or enhanced power management.**

**Observation 3.2:****In Rel-16, FDM is supported in granularity of a carrier (in term of an IAB-DU cell) for both semi-static resource configuration and DCI2\_5.** * **For semi-static resource configuration, IAB-DU resource types (Hard/Soft/NA) are configured per DU cell.**
* **For DCI2\_5, a set of DU cells can be configured to be indicated with availability indication from parent node.**

**For both cases, a DU cell can be a carrier in frequency domain, which is OAM configured and reported to CU.****Observation 3.3:****FDM in RB level within a carrier can provide more flexibility for interference management than FDM in carrier level alone, especially for FR2 with relatively large channel bandwidth of 50, 100, 200, 400MHz.****Observation 3.4:****The following factors needs be considered to support FDM in RB level within a carrier:*** **Flexibility to support coexistence of TDM resources and simultaneous operation resources with SDM/FDM.**
* **Flexibility to support possible common RBs cross IAB-DUs for cell-specific signals, e.g. cell-defined SSB for initial access.**
* **Compatibility with UE-specific bandwidth part framework.**

**Proposal 3.1:****Extend Rel-16 IAB resource management framework from per DU cell to per “DU RB set”, where a “DU RB set” can be configured by CU as a set of consecutive RBs within a DU cell.** * **The extension can be done for semi-static IAB-DU resource configuration and/or DCI2\_5.**

**Observation 4.1:** * **The efficiency of operating in enhanced multiplexing modes depends on the communication configuration (e.g. TX/RX beamforming) and may change over time.**
* **An IAB-node, at times and for given configurations, may not be able to effectively operate in an enhanced multiplexing mode whose support has been previously indicated as a capability to the network**

**Proposal 4.1:** **Support local refinement indication between parent and child nodes (e.g. via MAC-CE) for simultaneous operation:*** **to dynamically indicate whether the semi-static capability for enhanced multiplexing is applicable over time.**
* **to specify conditions required to realize the enhanced multiplexing capability, e.g. timing mode and/or TX power constraints.**

**Proposal 4.2:** **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 or per child node by donor CU to an IAB-node DU.**
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| NTT DOCOMO (R1-2101628) | **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.****Proposal3: If case#6 timing mode is required for simultaneous Tx, simultaneous MT-Tx/DU-Tx can be performed only if case#6 UL Tx timing is indicated by parent node; otherwise, simultaneous Tx cannot be performed, i.e. on DU hard/soft-IA symbol, only DU can Tx; on DU NA/soft-INA symbol, only MT can Tx.****Proposal4: Based on the above analysis, Rel-17 multiplexing cases are applicable to DL/UL slot and backhaul/access link as in the following table, and potential enhancements on timing and power control need to be studied.**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 | Yes, only if case#7 timing supported by access UE | 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  | / |

**Proposal5: Both semi-static configuration and dynamic indication of frequency resource availability for IAB node DU should be considered to support FDM resource multiplexing.****Proposal6: Support H/S/NA resource types configuration for DU frequency resources. H/S/NA resource types can be configured per RB group.****Proposal7: DCI format 2\_5 can be reused for dynamic indication of availability for soft frequency resources. Following options can be considered.*** **Option1: separate indication for time and frequency resource. AI index field in DCI format 2\_5 indicates the availability indication for soft symbols and the availability indication for soft frequency resources.**
* **Option2: joint indication for time and frequency resource. AI index field in DCI format 2\_5 indicates the availability for soft time-frequency resources.**

**Proposal8: For the dynamic indication of frequency resource multiplexing, granularity in frequency domain can be per RB group, which is the same as semi-static configuration. In time domain, the dynamic indication can be per resource type in each slot as in Rel-16.**  |
| Ericsson (R1-2101695) | [Proposal 1 Specify H/S/NA attributes for IAB-DU frequency-domain resources.](#_Toc61903474)[Proposal 2 The frequency-domain H/S/NA is indicated per IAB-RBG, the size of which contains integer multiples of the RBG size configured for access UE frequency-domain resource allocation.](#_Toc61903475)[Proposal 3 If a resource is configured as Hard, the IAB-DU can transmit, receive, or either transmit or receive according to its configuration only if it does not impact the IAB-MT’s ability to operate in any other resource according to the configuration of that resource.](#_Toc61903476)[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).](#_Toc61903477)[Proposal 5 A default resource attribute for the IAB-DU H/S/NA resource configuration is Soft.](#_Toc61903478)[Proposal 6 A frequency-domain DU resource assigned to cell-specific/semi-static signals/channels, such as SSB transmission, PRACH reception, PDCCH transmission for Type0-PDCCH CSS sets, is always treated as if it was configured as a Hard DU resource.](#_Toc61903479)[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.](#_Toc61903480)[Proposal 8 For IAB-MT 1) an indicated UL symbol overrides the configured SSB reception; 2) an indicated DL symbol overrides the configured PRACH transmission; 3) an indicated UL symbol overrides the configured SI reception.](#_Toc61903481)[Proposal 9 The parent node is dynamically provided with changes of the IAB-node’s multiplexing-capability.](#_Toc61903482)[Proposal 10 Time-domain H/S/NA configuration is always provided to the IAB-node even if ”TDM not required” is indicated to the IAB-donor-CU.](#_Toc61903483)[Proposal 11 Frequency-domain H/S/NA configuration is additionally provided to the IAB-node which has indicated “TDM not required” to the IAB-donor-CU.](#_Toc61903484)[Proposal 12 The parent node is aware of all IAB-DU resource configurations, including both time-domain and frequency-domain H/S/NA configurations, if provided.](#_Toc61903485)[Proposal 13 RAN1 should consider DCI-based signaling for explicit availability indication of frequency-domain Soft resources.](#_Toc61903486)[Proposal 14 Desired/Provided Guard Symbols are signaled in multiple groups that covers all switching combinations among Case #1, Case #6 and Case #7 timing alignment.](#_Toc61903487)[Proposal 15 It is assumed that to determine the availability of the per-cell DU soft resource by explicit indication, the IAB node should take into consideration of all received DCI format 2\_5 from collocated MT carriers associated to the same DU cell.](#_Toc61903488) |

**ISSUE 2.1: FREQUENCY DOMAIN MULTIPLEXING RESOURCE GRANULARITY**

**FL Proposal 2.1.1: The semi-static DU H/S/NA resource type indication is extended to frequency-domain resources. The following candidate solutions are considered:**

* **Alt. 1: RB-based**
* **Alt. 2: RBG-based**
* **Alt. 3: BWP-based**

**FFS: relation with DU time domain resource configurations and multiplexing capability indications**

**Discussion: Views on proposal 2.1.1?**

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| **Company**  | **Comments**  |
| **ETRI** | **We support the main bullet.****Regarding the candidates, we think the following alternative also can be considered:*** **Alt. 4: CC-based**
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| **Ericsson** | We consider the RBG or a **set of RBG** will match UE scheduling granularity, thereby avoiding poor resource utilization in addition to avoid involving too much overhead.Furthermore, for separated MT and DU, **there may be need for a guard band** such that any interference is maintained within the Hard spectrum.ETRI’s fourth alternative is not applicable, we think, since the fundamental assumption on H/S/NA is that it takes place within a single carrier. Different carriers are handled in the DC discussion. |
| **Nokia** | Support the FL proposal and alternatives listed. Carrier-based split between for IAB MT and Du can be already handled with existing signaling.**In the RAN1 GTW session, the following was used,** **Working Assumption**The semi-static DU H/[S]/NA resource type indication is extended to frequency-domain resources within a carrier.* FFS: relation with DU time domain resource configurations and multiplexing capability indications
* FSS: consider the implication of guard band (if needed)
* FFS: extension of FDM across carrier

We think that having TDM only resource types for a given carrier will not enable FDM operation. When the carrier size is large, a significant resource inefficiency may arise, primarily if the IAB node can support FDM mode, as the specification does not allow splitting of the frequency domain resources. Companies were questioning the specification effort, but we think that is not a big concern. For example, a given set of PRGs or RBs can be used as the resource partitioning granularity, where each group of PRGs or RBs can have an assignment of H, S, NA resource types. We could expect CU to assign a contiguous set of PRGs for the access link and another set of contiguous PRGs for the backhaul link. This indication could apply for DL and UL slots in the time domain for defined time granularity. For example, time granularity could be TDD configuration periodicity or any other periodicity, where Frequency domain availability may not differ for a given slot type. In summary, we think that it is worth RAN1 to spend time on specifying efficient FDM operation.  |
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**FL Proposal 2.1.2**

**The semi-static DU H/[S]/NA resource type indication is extended to frequency-domain resources within a carrier (in addition to existing Rel-16 per-carrier granularity).**

**FFS: Granularity for frequency domain resources within a carrier, including the following options:**

* **Alt. 1. RB-based**
* **Alt. 2. RBG-based**
* **Alt. 3. BWP-based**

**FFS: relation with DU time domain resource configurations and multiplexing capability indications**

**FFS: impact of guardband (if needed)**

**FFS: extension of FDM across carriers**

**Discussion: Views on proposal 2.1.2?**

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| **Company**  | **Comments**  |
| **AT&T** | **Agree with comments from Nokia from GTW. Time domain granularity does not have to be the same for frequency domain indications and the periodicity could also be independent to reduce signaling overhead. Allocating separate carriers for access/backhaul is very inefficient, especially considering the backhaul traffic volume may be much larger than what is allocated to a single access UE due to aggregating multiple UEs/child IAB nodes. At the same time to alleviate concerns about overhead/complexity we see Alt. 2 is a good starting point for compromise.** |
| **Intel** | We agree with the FL proposal. |
| **Qualcomm** | We support FL proposal 2.1.2. |
| **Samsung** | In terms of allocating separate carriers, for FR2, there are only limited options for channel BW. We feel sympathy about resource inefficiency by using separate carriers for FR2. On the other hand, we see there are so many options for channel BW for FR1 (e.g., 5, 10, ~, 100). So, we don't see a point at least for FR1. |
| **NTT Docomo** | We support FL proposal.  |
| **vivo** | We support the feature. H/S/NA property can be used to control the resource splitting b/w DU and MT. it can achieve FDM resource splitting to minimize interference b/w DU and MT; it can be a tool to control the portion of SDMed resource, compared with purely adaptation of MT-BWP, it is more flexible for load balancing b/w DU and MT.Regarding the granularity, RB-level or RBG-level can be further considered for DU resource conf.. BWP-level is the same as RBG-level from resource configuration perspective. BWP function is essential for UE/MT operation, we are not clear about the motivation to introduce BWP to DU side, we prefer NOT to use such sensitive wording i.e., no BWP-based |
| **Lenovo, Motorola Mobility** | We agree with the proposal and agree with companies’ remarks that the main applicability here is within a CC, so the three bullets are appropriate.Regarding [S] in the frequency domain, it may be beneficial to discuss Issue 2.4 first before deciding exactly how many resource types to support in the frequency domain. For example, in the case of separate configuration/indication, H/S/NA seems a good starting point. But in the case of joint configuration/indication, having a combination of H/S/NA in both domains (and possibly even in the spatial domain!) seems an overkill. In the latter case, {available/hard, not-available} in the frequency domain may be a more practical choice. |
| **ZTE, Sanechips** | Agree with the FL proposal, as we pointed during GTW, FFS whether soft resource type indication in frequency-domain is needed.  |
| **Huawei** | As discussed in the GTW, we think it would good to have a further discussion on the potential benefit and the detailed scheme to support FDM within a carrier (our observation is that companies have very diverse views in mind). Some detailed comments below1. Firstly, regarding the point mentioned by AT&T that “the backhaul traffic volume may be much larger than what is allocated to a single access UE due to aggregating multiple UEs/child IAB nodes”, we would like to point out the IAB-DU is not serving one access UE or child node, it serves all UEs and downstream child nodes. The traffic should be more or less balanced between MT and DU.
2. FDM across different carriers is support in Rel-16, i.e. when the MT CC and DU cell are in different bands or in different carriers of the same band but have good isolation. The motivation of supporting FDM within a carrier should be clarified. We would like to see more detailed examples like how “greater flexibility”, “reduced CLI” can be achieved compared to TDM. It should be noted that FDM within one carrier is also possible by configuring non-overlapping BWPs for IAB-MT and child IAB-MT/access UEs. It is not clear why additional signaling is required to support such case.
3. For FDM within one carrier, the resource efficiency does not seems to be promising compared to TDM. FDM operation may require guard band between MT and DU in addition to guard symbols compared to TDM. The required guard band to operate FDM may be dynamic and dependent on the Tx/Rx power imbalance between MT and DU. It is not possible to inform the CU in a dynamic manner and the CU may have to assume the worst case and resource efficiency of FDM is questionable compared to TDM, where the guard symbols are more or less stable.
4. The co-existence of TDM and FDM should be clarified. According to the discussion in issue#2.5, it seems that the multiplexing capability may change over time. If one IAB node switch FDM and TDM from time to time, the available bandwidth for IAB-DU will also be changing. This will have an impact on transmission and reception of signals/channels for IAB-DU with higher-layer configured bandwidth should be studied further. Specifically, the FDM with granularity of RB or RBG will make the frequency domain resource of DU more fragmented, and therefore the resource indication and allocation of IAB-DU will be quite challenging, if not impossible, in frequency domain. For example, the bandwidth of the CORESET is configured by RRC and cannot be changed dynamically, and if intra-CC FDM is supported in some slots, the IAB-DU may not be able to transmit PDCCH in those slots.
5. It is not clear whether the backward compatibility to Rel-16 H/S/NA concept can be ensured. According to the contributions from some companies, it seems that the IAB-DU may not use a Hard resource due to guard band issues and essentially has to be make sure the IAB-MT is not impacted, which essentially become a soft resource.

In summary, we are still unsure about the performance benefit and specification impact to support FDM within one carrier. It would be good to have more detailed discussion on this considering detailed schemes proposed by different companies. |
| **Fujitsu** | We generally agree with the FL proposal. Regarding the necessity of soft resource for FDM, the first step would be to clarify the behavior with regard to soft resource in Time domain in the context of simultaneous operation. |
| **LG** | We support the FL proposal.In addition, we support to introduce S resource type in frequency domain, it seems useful in terms of resource flexibility.Related to the discussion, we want to clarify whether the frequency domain H/S/NA resource type is applied to a symbol(s) for FDM operation only or not. In our view, for non-FDM operation, frequency domain H/S/NA resource type does not need to be applied. In that case, MT and DU can utilize frequency resource regardless of frequency domain H/S/NA resource type. |
| **Ericsson** | We support the FL proposal although we don’t think all topics for FFS are actually needed. Furthermore, we think **the brackets around the Soft indication should be removed**. Alike TDM, being able to balance resources between MT and DU sides makes a lot of sense to us. Huawei correctly points out that traffic should be approximately equal between the MT and DU sides. However, the different DU and MT side channels are neither capacity-wise equal, nor static, and hence, the amount of resources required for the approximately equal traffic, may differ significantly. |
| **CEWiT** | We agree with FL proposal |

**FL Proposal 2.1.3**

**The semi-static DU H/S/NA resource type indication is extended to frequency-domain resources within a carrier (in addition to existing Rel-16 per-carrier granularity).**

**FFS: Granularity for frequency domain resources within a carrier, including the following options:**

* **Alt. 1. RB-based**
* **Alt. 2. RBG-based**
* **Alt. 3. BWP-based**

**FFS: relation with DU time domain resource configurations and multiplexing capability indications**

**FFS: impact of guardband (if needed)**

**FFS: extension of FDM across carriers**

**FFS: Different handling of FDM resources in case of soft vs. hard/NA indications**

**FFS: Restrictions on band/minimum bandwidth for FDM operation (e.g. FR2 100MHz+ etc.)**

**Discussion: Views on proposal 2.1.3?**

|  |  |
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| **Company**  | **Comments**  |
| **Ericsson** | We **agree** to the FL proposal. Furthermore, we can already now agree to **RBG-based** frequency domain resource indication. |
| **Intel** | We agree to the FL proposal. |
| **vivo** | Agree. For clarification that BWP-based means MT BWP-based |
| **CEWiT** | We agree to the FL proposal |

**Possible Working Assumption**

The semi-static DU H/[S]/NA resource type indication is extended to frequency-domain resources within a carrier (in addition to existing Rel-16 per-carrier granularity).

* Granularity for frequency domain resources within a carrier is a set of N RBGs (FFS: value of N >=1)
* FFS: Relation with DU time domain resource configurations and multiplexing capability indications
* FFS: Impact of guardband (if needed)
* FFS: Extension of FDM across carriers
* FFS: Different handling of FDM resources in case of soft vs. hard/NA indications
* FFS: Restrictions on band/minimum bandwidth for FDM operation (e.g. FR2 100MHz+ etc.)

Supported by AT&T, Ericsson, Nokia/NSB, ETRI, LGE, Qualcomm

Concerns raised by Huawei/HiSi

**Proposal 2.1.4**

**Further consider support for the extension of semi-static DU H/[S]/NA resource type indication to frequency-domain resources within a carrier (in addition to existing Rel-16 per-carrier granularity) including the following aspects:**

* **Granularity for frequency domain resources within a carrier is a set of N RBGs (FFS: value of N >=1)**
* **Relationship with Rel-16 DU H/S/NA resource type indications in case of coexistence between TDM and FDM operation, including time-granularity of switching between multiplexing options and any other requirements to ensure backwards compatibility with Rel-16 IAB nodes and avoid impact on access UEs**
* **Different handling (if needed) of FDM resources in case of soft vs. hard/NA resource type indications**
* **In case frequency-domain extension is supported for soft resources, enhancements for DCI format 2\_5 to support dynamic indication of availability for soft frequency resources.**
	+ **Alt. 1 Separate indication of time and frequency resources**
		- **FFS: different field, RNTI or different DCI**
	+ **Alt. 2 Joint indication of time and frequency resources**
		- **FFS: backwards compatibility with Rel-16**
* **FFS: Impact of guardband (if needed)**
* **FFS: Extension of FDM across carriers**
* **FFS: Restrictions on band/minimum bandwidth for FDM operation (e.g. FR2 100MHz+ etc.)**

**Discussion: Views on proposal 2.1.4?**

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| **Company**  | **Comments**  |
| **Huawei** | We appreciate ATT’s effort in organizing the discussion. Maybe I can elaborate our comments to FDM within one carrier with more details even though I believe most of them have been mentioned before. Let us see whether we can resolve it with more discussions.* **Performance benefit**: FDM across different carriers is support in Rel-16, i.e. when the MT CC and DU cell are in different bands or in different carriers of the same band but have good isolation. The motivation of supporting FDM within a carrier seem to be “greater flexibility”, “reduced CLI”, etc. However, it is not clear how much it would actually bring compared to TDM where the resources can be flexibly divided among parent and child links in time domain.
* **Resource efficiency**: For FDM within one carrier, the resource efficiency does not seems to be promising compared to TDM. Of course, there are indeed cases whether guard band is not required. However, we think the most typical case is that FDM operation within a carrier would require some guard band between MT and DU in addition to guard symbols compared to TDM. The required guard band to operate FDM may be dynamic and dependent on the Tx/Rx power gap between MT and DU. It is not possible to inform the CU in a dynamic manner and the CU may have to assume the worst case and resource efficiency of FDM is questionable compared to TDM, where the guard symbols are more or less stable.
* **Feasibility**: One fundamental question is how one will operate FDM within one carrier. According to the GTW discussion and company contributions. It seems that there are mainly two possible ways
	+ The first way is semi-static FDM where the frequency resources are semi-statically divided between parent and child links. Our understanding is that this mode is only possible when no guard band is required or a fixed (conservative) guard band is reserved. However, semi-static FDM within one carrier can readily by implementation, e.g. by configuring non-overlapping BWPs for IAB-MT and child IAB-MT/access UEs. It is not clear why additional signalling is required to support this case.
	+ The second way is dynamic FDM where the frequency resources can be dynamically shared between the parent link and child link. This also cover the case of dynamic switching between FDM and TDM. In case the available resource at an IAB-DU is changing from time to time, the frequency domain resources that can be used by child IAB-MT/Access UEs are also changing. This has a significant impact on the transmission and reception of signals/channels with higher-layer configured bandwidth for IAB-MT/Access UEs. How this is handled would require either multiple RRC configurations or truncating the channel/signals which does not seem to be feasible. As one example, the bandwidth of the CORESET is configured by RRC and cannot be changed dynamically, and if FDM within one carrier is supported in some slots, the IAB-DU may not be able to transmit PDCCH in those slots.
* **Backward compatibility**: It is not clear whether the backward compatibility to Rel-16 H/S/NA concept can be ensured. According to the contributions from some companies, it seems that the IAB-DU may not use a Hard resource due to guard band issues and essentially has to be make sure the IAB-MT is not impacted, which essentially become a soft resource.

With on the above understanding, we are still not convinced that the extension of semi-static DU H/[S]/NA resource type indication to frequency-domain resources is feasible or beneficial. Therefore, we would like to suggest the following changes:**Proposal 2.1.4****Further consider whether/how to support FDM ~~support for the extension of semi-static DU H/[S]/NA resource type indication to frequency-domain resources~~ within a carrier (in addition to existing Rel-16 per-carrier granularity) including the following aspects:*** **Necessity and feasibility for extension of semi-static DU H/[S]/NA resource type indication to frequency-domain**
	+ **FFS: Compatibility with Rel-16 time domain DU H/S/NA resource types**
* **Granularity for frequency domain resources within a carrier is a set of N RBGs (FFS: value of N >=1)**
* **Relationship with Rel-16 DU H/S/NA resource type indications in case of coexistence between TDM and FDM operation, including time-granularity of switching between multiplexing options and any other requirements to ensure backwards compatibility with Rel-16 IAB nodes and avoid impact on access UEs**
* **Different handling (if needed) of FDM resources in case of soft vs. hard/NA resource type indications**
* **In case frequency-domain extension is supported for soft resources, enhancements for DCI format 2\_5 to support dynamic indication of availability for soft frequency resources.**
	+ **Alt. 1 Separate indication of time and frequency resources**
		- **FFS: different field, RNTI or different DCI**
	+ **Alt. 2 Joint indication of time and frequency resources**
		- **FFS: backwards compatibility with Rel-16**
* **FFS: Impact of guardband (if needed)**
* **FFS: Extension of FDM across carriers**
* **FFS: Restrictions on band/minimum bandwidth for FDM operation (e.g. FR2 100MHz+ etc.)**
 |
| **NTT Docomo** | We support FL proposal.Regarding Huawei’s comments on semi-static FDM versus dynamic FDM and feasibility, in our understanding, dynamic FDM is needed to achieve more flexibility. Regarding the concern that dynamic FDM will impact on higher-layer configured Tx/Rx of child-MT/UE, in our understanding, similar issue also exists in dynamic TDM. In dynamic TDM, it is also possible that some symbols for high-layer configured Tx/Rx is not available for IAB-DU. Meanwhile, proper configuration can avoid the issue to some extent, e.g. the resources used for higher layer configured Tx/Rx can be configured in “hard” frequency resources, or for more important cell-specific channels/RS, it can be regarded as “hard” frequency resources.Regarding Huawei’s comments on impact from potential guard band, these issues can be discussed as next level details, for example, if guard band is needed, how to avoid the impact of guard band on the usage of hard resources. |
| **Ericsson** | We support the FL proposal although it does not make much progress from the below agreement from RAN1 #103-e:*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.*We have the following comments on Huawei’s concerns:Considering the **benefits** of simultaneous operation, we acknowledge that using multiple carriers is a feasible and even attractive solution that should be and is feasible. However, simultaneous operation in Rel-17 IAB should not be restricted to the assumption that dual or multiple carriers exist. Hence, it is our interpretation that FDM functionality supporting simultaneous operation within a carrier is an objective according to the WID. The third RAN1 meeting in Rel-17 is not the time or place to start discussing its benefits – they have been discussed and agreed earlier.Regarding **resource efficiency**, we think that guard bands *may* be needed for IAB nodes with separate MT and DU front ends, but even for such architectures that may not necessarily be the case. Even if guard bands are needed, a properly configured network would only require one such band, significantly reducing overhead. Any other resource allocation is not much different from TDMed resource allocation and, hence, signaling overhead should be approximately the same. We do not think that frequency resource sharing between MT and DU, if properly configured, requires a frequent semi-static resource reconfiguration by a CU.With respect to the **feasibility** of the proposal, we think that the Soft configuration is needed for the same reasons as why it was introduced in Rel-16 – to provide some flexibility in resource allocations. For configurations where it is ill-suited, it needs not be configured. Furthermore, we have the following concerns about using bandwidth parts (BWPs):* BWP was developed for UEs with limited capabilities. Using BWPs for semi-static resource allocation would pose unnecessary limitations on the network.
* BWPs are not slot specific and that will pose unnecessary restrictions on the network. One attractive network configuration is, e.g., to separate UE access traffic from backhaul traffic in different slots, in which case it would be preferred to use the full carrier for the UE access traffic. This would not be possible if the DU is restricted to use only a subset of the carrier. For that and other configurations, some slots would be restricted in its use due to the BWP configuration, thereby reducing performance.
* BWP is configured for UEs (MTs) but not DUs. Hence, the DU would still need a H/[S]/NA configuration to restrict its operation in order to FDM DU and MT operation.

Additionally, we have concerns for **backwards compatibility**, should BWPs be used for multiplexing simultaneous operation in IAB nodes. Considering BWP is a Rel-15 function that is not intended for IAB in the first place, we risk ambiguous behavior if, e.g., an IAB node needs to fall back to Rel-16 operation. How would the IAB know whether to maintain its BWP configuration in this case?We share Huawei’s view that proper behavior for both Hard and Not Available should be agreed, e.g., in relation to an existing guard band, but we don’t think that is an insurmountable task to sort out in a future meeting. |
| **Huawei** | Reply to DCM:1. We would like to highlight that TDM is very different from FDM since the bandwidth does not need to be adapted for the UE/child IAB-MT in TDM. For CSI-RS and SRS configurations which are typically across the whole bandwidth, it is not clear how they will be actually be transmitted in case of dynamic FDM. Note that this is also not a simple configuration issue for the IAB-DU if one have to ensure all the high-layer configured signals/channels for all UEs and Child IAB-MT are transmitted in Hard resource in particular in frequency domain. At the same time, this should be aware by the parent node, which is not an easy take either as explained in the next bullet.
2. In Rel-16, we do introduce some rules that some higher-layer configured cell-specific signals and channels such as SSB/PDCCH for RMSI/PRACH can be regarded Hard. However, the parent node needs to aware of these configurations. In particular, this implies that there will be quite some UE/Child-IAB specific configurations conveyed to the parent node. One may remember that we received an LS from RAN3 (R3-202859) last year asking whether it is possible to exclude the CSI-RS and SR configurations from the list of cell-specific signals/channels configurations since there was a big concern of signaling storm from RAN3 point of view. Now when it comes to FDM, almost all UE/IAB-specific higher-layer configured signals and channels need to be communicated between the parent node and IAB node. We don’t think this is even feasible.

Reply to Ericsson:1. Regarding the comment on **benefit**, strictly speaking, FDM within one CC was not evaluated during the SI. It was always bundled with SDM but for SDM the benefit of resource efficiency is easy to understand and there is not much analysis on FDM. In addition, we don’t think the WI objective explicitly emphasizes that FDM within CC and cross carrier should both be supported and optimized. In any case, TDM has already been specified in Rel-16. One would need to understand the tradeoff between specification effort and potential benefit compared to the existing scheme.
2. Regarding the comment on **resource efficiency**, it seem that the assumption is that this is more like a semi-static FDM configuration. As we comment earlier we see no issue when no guard band is required but we are more concerned on the case when guard band is required. Regarding the comment “*We do not think that frequency resource sharing between MT and DU, if properly configured, requires a frequent semi-static resource reconfiguration by a CU.*”, our understanding is that the required guard band to operate FDM would be dynamic and dependent on the Tx/Rx power gap between MT and DU, e.g. The DU Rx power will change dependent on actual scheduling. It is not possible to inform the CU in a dynamic manner and the CU may have to assume the worst case. In addition, there are a lot of possibilities for FDM operation within one carrier, e.g. two separate set of non-overlapping consecutive frequency resources for MT and DU, inter-leaved frequency resources for MT and DU. It is not clear whether the same guard band can be applied for all cases.
3. Regarding the comments on **feasibility**, it seems that there is a misunderstanding here. We were not proposing BWP for IAB-DU, we also think this is not the way to go. Our view is that the semi-static FDM within one carrier can readily by implementation, e.g. by configuring non-overlapping BWPs for **IAB-MT** and **child IAB-MT/access UEs**. This can be done already now and it is not clear why additional signaling is required to support this case.

Overall, we are still not convinced to go with the original proposal. The compromised proposal from us can still take us some step further since the key issues and design aspects have been listed and it could be a good starting point for further discussions.  |
| **Nokia, NSB**  | We support the FL proposal.   Regarding concerns about performance benefit.  FDM clearly offers increased flexibility over TDM within a slot, since the ability to subdivide frequency resources within a slot reduces scheduler constraint and enables more optimal resource allocation in dense deployments.  Regarding concerns about efficiency, we note that need for guard intervals/bands is a general issue with multi-access and should not preclude the support of FDM.  In scenarios where guard intervals limit the potential gains of FDM, fallback to TDM via resource designation over the full carrier should be an elegant and backward compatible approach.  In scenarios where the need for guards is minimal, the added efficiency of FDM is apparent.  And while guard bands may vary across the network, it is unclear why this would change dynamically.  Access links may require more conservative guard bands but backhaul links should largely be LOS with no mobility and should require minimal guard bands.  The topology of this network should be known by the CU.  Regarding feasibility, as discussed, the use of H/NA resources alone will enable greater flexibility with a slot and so therefore should be adopted.  S resources may pose additional technical challenges, but we believe that the benefits in dynamic flexibility clearly outweigh the challenges.  Even still, the study of frequency allocation for S resources has been left FFS and so should not preclude adoption of the proposal.  Regarding backward compatibility, there is no clear reason to believe that this should be an issue given proper configuration.  If conditions preclude the use of frequency designation for H resources, then implementation allows for strict TDM and the problem can be avoided.  |

**ISSUE 2.2: SPATIAL DOMAIN MULTIPLEXING RESOURCE GRANULARITY**

**FL Proposal 2.2.1: The semi-static DU H/S/NA resource type indication is extended to spatial-domain resources. The following candidate solutions are considered:**

* **Per-backhaul link indication**
* **Per-panel indication**
* **Per-beam indication**

**FFS: relation with DU time/frequency domain resource configurations and multiplexing capability indications**

**Discussion: Views on proposal 2.2.1?**

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| **Company**  | **Comments**  |
| **ETRI** | **We think further study on spatial-domain extension is more appropriate at this stage. The exact meaning of “per-backhaul link”, “per-panel”, or “per-beam” is not that clear. For instance, does “per-beam indication” mean that the IAB-DU can be configured or indicated DU resource types per SSB/CSI-RS?** |
| **Ericsson** | **We generally agree with the proposal, but we think this topic needs further study.**SDM has not been discussed very thoroughly so far in Rel-17 and it is a topic that may need more discussion. We identify (although not included in any proposal) that **H/S/NA configuration in its TDM or FDM versions is not applicable for SDM** since, in a pure SDM configuration, **a UE located along the link between the MT and parent DU may not be scheduled at all**. Hence, for some configurations, a fallback mechanism to FDM or TDM is likely required. In any way, interference will appear per link (or beam in case of analog BF), and we think that any indication should relate to that. Additionally, we think it would also be worthwhile to study **how to apply restrictions w.r.t. the BH link indication**, e.g., what parameter and/or metric to use. |
| **Nokia** | We think a further study on this should be the way forward here. First, it is hard for CU to define per beam/panel resource availability as the quality of a beam pair used for SDM Tx and SDM Rx, cannot be assumed to be known via a semi-static manner. Per-BH link indication is similar to per link DU configuration, where the motivation may be a bit different than just considering SDM operation. Even for TDM operation, such per link DU configurations could help.  |
| **AT&T** | Agree with the comment from Ericsson that enabling these indications likely needs support from measurements (e.g. CLI) or assistance information from the child, so this topic should be tightly coordinated with the related discussion in 8.10.2. |
| **Intel** | We basically agree with this FL proposal. Regarding the first bullet, we support per-link DU configuration not only in SDM operation similar as Nokia pointed out.  |
| **Qualcomm** | We support the proposal and agree with the comments from Ericsson and AT&T. |
| **Samsung** | Before agreeing the proposal, fine to further study. It would be good to have clear pictures about how to use these indication and what information is needed to indicate the indication |
| **NTT Docomo** | We think further study is needed.Similar view as Nokia, first we think it is hard for CU to make semi-static configuration of beam availability for DU.In our view, SDM can be supported in an implementation way. DU can decide how to schedule its child link based on its condition on parent link (e.g. beam indicated for MT).So, to discuss the enhancement on SDM, from our perspective, clarification is needed at least for the following assumptions and motivations. * Separate or shared panels are assumed to be used for MT and DU
* Same or different analog beams are assumed to be used for MT and DU for simultaneous MT Tx/Rx and DU Tx/Rx
* The motivation is to alleviate interference between MT Rx and DU Rx, or DU Tx to MT Rx, or CLI
* Etc.
 |
| **vivo** | The intention of spatial domain resource indication is to ‘turn off’ a certain panel or beam direction, which can minimize the relevant interference. So, we support to further study the per-beam or per-panel indication.Regarding per BH-link indication, DU may have multiple child nodes, each corresponds to a certain DU beam direction, thus per BH-link indication is purely spatial domain indication. The per-BH link indication is different from the per BH-link resource conf., which is another tool to control the time-frequency domain resource to mitigate interference, it may be jointly used with the spatial domain indication, but they are not the same concept. If our understanding is correct, we can support to further study the per-BH link indication. |
| **Lenovo, Motorola Mobility** | We do not agree with this proposal at this point and do encourage more study on the subject. The H/S/NA framework is practical in time and frequency domains because signals in these domains are well defined by the spec, and the definitions provide a sufficiently fine granularity that make the complexity of the approach worthwhile. The spatial domain lacks these desirable properties. Especially when it comes to semi-static signaling, this approach seems less practical for the spatial domain, and maybe even less so in the case of mobile IAB. Control signaling for panel and beam indications may be best managed by ‘local’ signaling, i.e., among child and parent nodes and possibly other nodes in the vicinity affecting or affected by interference, rather than semi-static signaling from the CU. We agree with companies’ remarks that this matter is tightly related to interference management. |
| **ZTE, Sanechips** | Need further study on this topic, unlike time/frequency domain resources, it is difficult for CU to semi-static control all the DUs’ resource availability on spatial-domain due to the time-variant channel conditions. |
| **Huawei** | As pointed out by many companies, the exact definition of different candidate solutions should be clarified. For example, the beam of IAB-DU is transparent in specification and typically should be agnostic to parent node and will be dynamically changed based on scheduling. Therefore, we are not sure how the per-beam resource configuration is even possible. In addition, we would like to point out that SDM can readily be supported based on the current Rel-16 H/S/NA TDM resource configuration. For example, for an IAB node supporting/indicating capability of simultaneous operation, the corresponding simultaneous operation can be supported on a Hard or S-INA (soft resource but indicated available) IAB-DU resource as long as it does not impact the Tx/Rx of IAB-MT based on its capability.  |
| **Fujitsu** | We are fine to further discuss the detailed operation of each candidate. |
| **LG** | It seems better to have further discussion, rather than agree on the proposal at this stage.  |
| **CEWiT** | We agree with the proposal as a starting point. Further study is needed as mentioned by Ericsson |

**Agreement**

Further study whether/how to manage resources in the spatial domain. Candidate solutions are:

* Dynamic signaling between parent and child nodes for using/restricting/sharing antenna panels/beams
* Beam management / multi-panel enhancements for simultaneous operations
* Extension of H/S/NA resource indication to the spatial domain

Other solutions are not precluded.

**ISSUE 2.3: HANDLING OF CELL-SPECIFIC SIGNALS/CHANNELS**

**FL Proposal 2.3.1: For all multiplexing modes, cell-specific/semi-static signals and channels of the IAB-DU shall be considered as hard resources (the same as in Rel-16) and simultaneous Tx/Rx operation is allowed for either the IAB-DU or IAB-MT based on the indicated multiplexing capability**

* **FFS: IAB-MT behavior in case of conflicts between cell-specific signals/channels and dedicated resource configurations**
* **FFS: Additional spatial domain restrictions (e.g. per SSB or access vs. backhaul link)**

**Discussion: Views on proposal 2.3.1?**

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| **Company**  | **Comments**  |
| **ETRI** | **Support the FL proposal in principle.****We suggest the following revisions on the main bullet:****~~For all multiplexing modes,~~ Regardless of simultaneous operation, cell-specific/semi-static signals and channels of the IAB-DU shall be considered as hard resources (the same as in Rel-16) and simultaneous Tx/Rx operation ~~is~~ can be allowed for ~~either~~ the IAB-DU and/or IAB-MT based on the ~~indicated~~ reported multiplexing capability** |
| **Ericsson** | We support the proposal.However, we notice that **we do not have any agreement about a general interpretation of H/S/NA utilization for simultaneous operation**, i.e., for what H/S/NA configurations is simultaneous operation actually allowed. This should also include any restrictions arising from interference in other resources (see comment in Proposal 2.1.1). |
| **Nokia** | **Support the proposal.** |
| **Intel** | We support the FL proposal.  |
| **Qualcomm** | We support the FL proposal with a slight preference for ETRI’s version.We think that “dedicated resource configurations” should be clarified in the first FFS point. |
| **Samsung** | OK with FL proposal or ETRI's revision. |
| **NTT Docomo** | Support. |
| **vivo** | For the first half of the main bullet, we agree that resource of cell-specific signaling (the same set as defined in Rel-16) is always ‘hard’, we also prefer to remove the wording ‘semi-static signaling’ to avoid misunderstandingFor the second half of the main bullet, the wording is saying ‘simultaneous TX/RX of cell-specific signaling is based on IAB node multiplexing capability’? if yes, we prefer to change the wording as pointed by ETRI.For the 1st FFS, we are not sure whether such case will occur or not by conf.; even if the conflict may occur, it should be discussed whether DU or MT to address the conflict. Therefore, we prefer more general wording for now, e.g., whether/how to address the cell-specific signals/channels conflict, if simultaneous TX/RX for the cell-specific signals/channels is not allowed based on multiplexing capability.For the 2nd FFS, the intention is not clear. Is it saying ‘the multiplexing capability is based on spatial domain restriction’. If our understanding is correct, such restriction can be discussed in the other issue for multiplexing capability indication  |
| **Lenovo, Motorola Mobility** | We support the FL proposal. We agree with companies’ suggestion to clarify “dedicated resource configurations” in the FFS point. |
| **ZTE, Sanechips** | Agree in principle, and we agree with the comment from Ericsson, we suggest to remove ‘....**~~and simultaneous Tx/Rx operation is allowed for either the IAB-DU or IAB-MT based on the indicated multiplexing capability~~**~~’~~ from the main-bullet. |
| **Huawei** | We are mostly fine with main bullet but also have a preference to ETRI’s version. Our understanding of the “dedicated resource configurations” in the first main bullet is the more related to dedicated slot configurations. If so, we are fine with the first FFS bullet. For the second FFS bullet, we think it is not relevant. The main bullet tries to clarify the relation between cell-specific signals/channels and HARQ resources. We suggest to remove it.  |
| **Fujitsu** | We support the FL proposal. |
| **LG** | We support the FL proposal in general.We want to clarify whether the proposal is only for time domain resource or can be applied to frequency domain resource also. |
| **CEWiT** | We support the proposal in general. We have the following concerns* The H/S/NA mentioned in the proposal refers to time domain or frequency domain is not clear. If refers to frequency domain, then H/S/NA is not defined so far.
* We would like to clarify meaning of the term “**indicated multiplexing capability”** in second part of main bullet. Does that mean capability reported by IAB node to network? If yes, then IAB cannot always operate in its reported capability. The active mode of IAB node depends on the multiplexing capability of IAB node and its parent, the resource configuration of IAB-MT and IAB-DU, the network condition etc.
 |

**Agreement**

Regardless of simultaneous operation, the same cell-specific/semi-static signals and channels of the IAB-DU considered as hard time/frequency resources in Rel-16 are also considered as hard time/frequency resources in Rel-17.

* FFS: IAB-MT behavior in case of conflicts between cell-specific signals/channels and other resource configurations of the IAB-MT (e.g., dedicated slot configurations)

**ISSUE 2.4: DCI FORMAT 2\_5 ENHANCEMENTS**

**FL Proposal 2.4.1: DCI format 2\_5 is extended to support dynamic indication of availability for soft frequency resources. The following solutions are considered:**

* **Alt. 1 Separate indication of time and frequency resources**
	+ **FFS: different field, RN or different DCI**
* **Alt. 2 Joint indication of time and frequency resources**
	+ **FFS: backwards compatibility with Rel-16**

**Discussion: Views on proposal 2.4.1?**

|  |  |
| --- | --- |
| **Company**  | **Comments**  |
| **ETRI** | **Support the FL proposal in general.****Regarding Alt. 1, we think one more proposal (new RNTI) also can be further considered.** |
| **Ericsson** | We support the proposal, prefer **Alt. 2.** |
| **Nokia** | Support the main bullet. We think Alt.2 can be backward compatible. May be rewording of Alts will clarify the details. * Alt. 1 Separate indication of availability of soft resources of time and frequency resources.
	+ FFS: how the resources in other domain is derived if only one availability indication is received
	+ ~~FFS: different field or different DCI~~
* Alt. 2 Joint indication of time and frequency resources
	+ FFS: how to extend the DCI format 2-5 while supporting backwards compatibility with Rel-16
 |
| **Intel** | We support the FL proposal, prefer Alt. 1.  |
| **Qualcomm** | We support in principle the FL proposal. We agree with and support Nokia’s suggested edits. |
| **Samsung** | We are open to discuss either Alts. But, it depends on whether an extension to freq. domain is agreed in Issue 2.1.1 |
| **NTT Docomo** | Support FL proposal. |
| **vivo** | We support the proposal  |
| **Lenovo, Motorola Mobility** | We support the proposal, possibly with a slight rewording for more clarification. Nokia’s edits suggest that we have already agreed to support [S] resources in the frequency domain. Those parts of the edits can be considered later.This graphic is to make sure we have a common understanding of joint vs. separate. According to our understanding, in the case of joint, attributes such as H/S/NA/IA/INA are indicated for certain time and frequency resources, so the attributes are not recognized outside of those ranges. In the case of separate, attributes are possibly indicated for larger sets in each of the two domains, and then attributes for each resource are inferred from the separate indications. Whether the actual signaling is joint or separate seems a secondary issue at this point. |
| **ZTE, Sanechips** | Disagree, whether soft resource type indication is extended to frequency domain resources is still FFS, and as pointed during the GTW discussion, the benefit to support this is also not clear. |
| **Huawei** | As commented to issue #2.1, we are not sure about the necessity to support FDM in one carrier. This can be decided after concluding issue #2.1. |
| **LG** | We support the FL proposal in general. |
| **CEWiT** | We support proposal in general. For the Alts, we support the rewording done by Nokia except for the FFS on Alt 1. IAB node need explicit indication of IA in either time or frequency domain, depending on the mode of operation. IA for the other domain can be derived implicitly. For e.g., IAB node in simultaneous mode does not need IA for time domain resource, as Tx/Rx using S resource in DU may not affect the Tx/Rx in MT. We prefer Alt 1 for the same reason. |

**ISSUE 2.5: MULTIPLEXING CAPABILITY INDICATION ENHANCEMENTS**

**FL Proposal 2.5.1: Support dynamic indication between parent and child nodes of multiplexing capability in case of simultaneous operation. The following solutions are considered:**

* **Temporal applicability of a given multiplexing capability**
* **Time/frequency resource restrictions (e.g. access vs. backhaul links, DL vs. UL resources)**
* **Indications of conditions required to realize the a given multiplexing capability, (e.g. timing, power control, guard symbols, etc.)**

**Discussion: Views on proposal 2.5.1?**

|  |  |
| --- | --- |
| **Company**  | **Comments**  |
| **ETRI** | **At this stage we don’t understand what kind of channels/signals will be used for this dynamic indication.****Regarding the capability signaling, we think the existing F1AP specification, which seems to be non-dynamic, should be the baseline first.** |
| **Ericsson** | We support the proposal provided other solutions are not precluded. |
| **Nokia** | Support the following formulation as the proposal is not specific and not clear what is covered or not. FL Proposal 2.5.1: Support ~~dynamic~~ the indication/reporting of information that limit ~~between parent and child nodes of~~ a multiplexing operation ~~capability~~ for case A and B. ~~in case of simultaneous operation.~~ The following are ~~solutions~~ considered for indicating/reporting of information:* Temporal applicability of a given multiplexing capability and applicable conditions.
* Applicable conditions may contain,
	+ For FDM operation, IAB-DU/MT power control setting information
	+ For SDM operation, inability to operate in given set of activated beams
	+ FFS: For both FDM and SDM, timing and/guard symbols related information
* FFS: channels/signals used for indicating/reporting information
* ~~Time/frequency resource restrictions (e.g. access vs. backhaul links, DL vs. UL resources)~~
* ~~Indications of conditions required to realize the a given multiplexing capability, (e.g. timing, power control, guard symbols, etc.)~~
 |
| **Intel** | We support this FL proposal in general, but have concern on necessity of the second bullet.  |
| **Qualcomm** | We support the FL proposal in principle. We agree with Nokia’s suggested form, except we don’t think this should be restricted to case A and case B, it should apply to all 4 multiplexing cases. |
| Samsung | We also see indication itself is needed. But, it is unclear why it should be dynamic. In this sense, we are fine with Nokia's suggestion. |
| **NTT Docomo** | Agree with revision from Nokia. But the indication/reporting of power/timing related information may be up to 8.10.2. |
| **vivo** | Both semi-static and dynamic indication of multiplexing capability should be further considered. It can be dynamic nature based on condition to decide the temporal applicability. Also, a certain multiplexing case can be controlled semi-statically by NW depending on NW interference management or resource management.Moreover, the timing to apply a certain multiplexing case should be indicated as well. i.e., even though semi-static/dynamic simultaneous operation capability can be applied, IAB node can still assume that such simultaneous operation does not actually occur sometimes, this is determined by traffic load of AL and BH link. The benefits to restrict the timing is help IAB to adjust transmission parameters, e.g., in the duration of simultaneous operation, DU/MT TX power should be low or low MCS should be used to cope with the interference, while such transmission para. is not so tightly restricted for TDM duration. Based on above, we add another example as following* **Time/frequency resource restrictions (e.g. access vs. backhaul links, DL vs. UL resources, time resource to apply a certain multiplexing case)**
 |
| **Lenovo, Motorola Mobility** | We support the proposal and we understand that the list is not exclusive. |
| **ZTE, Sanechips** | We support the version form Nokia in general. |
| **Huawei** | **Agree.** However, we think at least the first solution alone cannot solve the issue. For example, if the applicability of simultaneous operation depends on some dynamic restrictions/conditions, the temporary applicability cannot be guaranteed without the awareness of the restrictions/conditions of parent node. |
| **Fujitsu** | We support the FL proposal. |
| **LG** | We support the FL proposal in general. Also, we are fine with Nokia's suggested form. But, as mentioned by Qualcomm, it should apply to all four cases of multiplexing. |
| **CEWiT** | We support FL proposal in general. We are ok with the rewording done by Nokia. However, it should be applicable for all multiplexing cases. |

**FL Proposal 2.5.2: Support indication/reporting of information between parent and child nodes to assist in the determination of the applicability of a given multiplexing capability in case of simultaneous operation. The following solutions are considered (other solutions not precluded):**

* **Temporal applicability of a given multiplexing capability**
* **Time/frequency resource restrictions (e.g. access vs. backhaul links, DL vs. UL resources)**
* **Indications of conditions/reporting information required to realize the given multiplexing capability, (e.g. timing mode, power control, guard symbols, etc.)**
* **FFS: channels/signals used for indicating/reporting information**

**Discussion: Views on proposal 2.5.2?**

|  |  |
| --- | --- |
| **Company**  | **Comments**  |
| **Ericsson** | We agree to the FL proposal. |
| **Intel** | We generally agree the FL proposal. Just to make sure the phrase of “parent and child nodes” will not cause any confusion, since usually we have:  parent IAB node <-> IAB node <-> child IAB node So we are suggesting change the main proposal as below**Support indication/reporting of information between** ~~parent and child nodes~~**IAB node and its parent node to assist ….**But if other companies think there will be no confusion, we are fine with current proposal.  |
| **vivo** | Agree  |
| **CEWiT** | We agree with FL proposal |

**Agreement**

Support indication/reporting of information between an IAB node and its parent node to assist in the determination of the applicability of a given multiplexing capability in case of simultaneous operation. The following solutions are considered (other solutions not precluded):

* Temporal applicability of a given multiplexing capability
* Time/frequency resource restrictions (e.g. access vs. backhaul links, DL vs. UL resources)
* Indications of conditions/reporting information required to realize the given multiplexing capability, (e.g. timing mode, power control, guard symbols, etc.)

FFS: channels/signals used for indicating/reporting information

# 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.**

**Summary of input contributions:**

|  |  |
| --- | --- |
| **Huawei (R1-2100219,R1-2101259)** | ***Proposal 7:*** *For inter-carrier intra-band DC, simultaneous Rx/Tx is not supported in Rel-17 for IAB.****Proposal 8:*** *In case of inter-carrier intra-band DC, the IAB-DU may use a soft symbol if the IAB-MT detects both DCI format 2\_5 with an AI index field value indicating the soft symbol as available.****Proposal:*** *For inter-carrier inter-band DC, an IAB node is not expected to receive two DCI format 2\_5 from MCG and SCG indicating the resource availability for a same IAB-DU soft symbol in Rel-16.* |
| **Vivo (R1-2100463)** | **Proposal 7: Send LS to RAN2/3 to inform that inter-donor DC operation can be supported from RAN1 perspective.** **Observation 2: Current NR-DC requires two legs to use different carrier, which means NR-DC is not available when single carrier is deployed according the current spec, while intra-frequency DC can remove this barrier.** **Proposal 8: RAN1 supports both intra-carrier DC and inter-carrier DC.** **Proposal 9: 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 10: 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., DCI\_format 2-5) from MCG and SCG.**  |
| **Intel (R1-2100670)** | **Proposal 5:** For DCI format 2\_5 in multi-parent scenarios, some options can be further discussed. * Option 1: when one parent DU transmits DCI format 2\_5 to an IAB MT, all other parents are informed.
* Option 2: DCI format 2\_5 can be transmitted by only one parent.
* Option 3: New rules can be defined for an IAB MT after receiving DCI format 2\_5 from multiple parents.

**Proposal 6:** Further discussion on support of Case#7 timing for IAB dual-connectivity scenarios is needed. **Proposal 7:** For the semi-static DU resource configurations, additionally support per-link configuration.  |
| **LG (R1-2100717)** | **Dual-connectivity to support multiple parent DUs*****Observation 2:**** For supporting two parent nodes belonging to each of two different donors, each CU should share the configuration information of all DUs from the belonging CU to neighbour CU which includes DU(s) for multi-parent operation.

***Proposal 7:*** For operating inter-carrier, intra-band DC scenario for FR2, it needs to clarify MT operation for transmission and reception in terms of antenna configurations (e.g., same panel/separate panel for multiple carriers) and combination of carriers.***Proposal 8:*** Study the solution for scheduling collision between two parent DUs due to indication of the resource availability for soft symbol(s) to the IAB-DU(s) by DCI format 2\_5. |
| **AT&T (R1-2100777)** | **Proposal 4: Per-backhaul link resource configurations and multiplexing capability indications independent of the per-IAB-DU configuration and multiplexing capability indication are supported in Rel-17. Coordination signaling to exchange the resource configurations and multiplexing capability indications between up to two parent IAB-nodes/donors should be additionally supported in Rel-17.****Proposal 5. For multi-parent features defined in RAN2/RAN3 (e.g. DC/DAPS/Multi-MT) in Rel-17, RAN1 should not preclude intra-carrier operation via implementation and reuse of solutions supporting inter-carrier operation.**  |
| **Nokia, Nokia Shanghai Bell (R1-2100833)** | **Proposal 3.1: RAN1 to proceed with other scenarios while waiting for further guidance from RAN on intra-carrier DC.****Proposal 3.2: In inter-carrier DC, the indication of availability of soft resources via DCI format 2-5 from a parent node is only valid for the IAB-DU cell(s) which uses the same carrier(s) in the backhaul link for the same parent.** **Proposal 3.3: IAB-MT shall support both single DCI based and multi-DCI based multi-TRP transmission schemes.** **Proposal 3.4: 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 DCI 2-5 indications allowing the use of the soft resource are received from both TRPs.**  |
| **ZTE, Sanechips (R1-2100958, R1-2100960)** | [*Proposal 6:* It is up to RAN3 to determine whether inter-donor inter-carrier DC is supported.](#_Toc21451)[*Proposal 7:* The explicit indication of soft time domain resources by DCI Format 2\_5 is reused for multi-parent scenarios in Rel-17. There is no need to consider additional enhancements over the Rel-16 solution.](#_Toc18001)[*Proposal 8:* From RAN1 perspective, inter-carrier, intra-band DU should reuse solutions for supporting Inter-carrier, inter-band. There is no need to introduce specific enhancements for inter-carrier, intra-band DC in Rel-17.](#_Toc22127) |
| Lenovo, Motorola Mobility (R1-2100990) | Proposal 6: Support intra-carrier DC at least to the extent that solutions for inter-carrier DC are reused.Proposal 7: Define signaling for IAB nodes in the DC mode to inform parent IAB nodes of the status of availability of soft resources. |
| ETRI (R1-2101083) | ***Proposal 4: Consider to handle intra-carrier DC in the future releases****Joint operation of “mTRP” + “Rel-16 TEI on half duplex CA” can be a good starting point for dual parent IAB via intra-carrier DC* |
| Samsung (R1-2101227) | ***Proposal 4: Focus on the inter-carrier DC scenario in RAN1#104-e.******Proposal 5: Send LS to RAN3 that inter-donor multi-parent operation can be supported in Rel-17 with a spec. support for inter-donor resource coordination.******Proposal 6: Discuss whether or not separate signaling between IAB MT and different parent IABs are necessary in Rel-17.******Proposal 7: Discuss how to address scheduling collision issues for child IAB between MCG and SCG.*** |
| Qualcomm (R1-2101483) | **Observation 2.1:****In Rel-16, following operations for NR-DC are specified in spec with some features missing support for intra-band inter-carrier NR-DC.** * ***RAN1:* UE TX power sharing specification defined for NR-DC is general and can be applied for intra-band inter-carrier DC.**
* ***RAN1:* The handling of potential TDD confliction between serving cells is specified within CA framework but is not specified for NR-DC.**
* ***RAN4:* The band configuration and RRM requirements (e.g. MTTD and MRTD etc.) defined for NR-DC are limited for inter-band NR-DC (only within FR1 bands and between FR1 and FR2 bands) and are not specified for intra-band inter-carrier NR-DC.**
* ***Higher layer:* Some of UE/MT capabilities defined for NR-DC are described in term of inter-band NR-DC and are not appliable for intra-band inter-carrier NR-DC.**
	+ **E.g. *ca-parametersNRDC,* *asyncNRDC-r16, etc.***

**Proposal 2.1:****To support intra-band inter-carrier NR-DC, Rel-16 handling of potential TDD confliction due to half-duplex operation for CA framework shall be extended to NR-DC between cell groups.****Proposal 2.2:****RAN1 shall coordinate with RAN4 and higher layer for support of intra-band inter-carrier NR-DC with at least following aspects:*** **E.g. adding band configuration and RRM requirements for intra-band inter-carrier NR-DC.**
* **E.g. Updating related UE/MT capabilities for NR-DC so that they are applicable for intra-band inter-carrier NR-DC.**

**Observation 2.2:****In Rel-16, if a soft resource is not explicitly indicated as available by DCI2\_5, an implicit method will be used by IAB-node for determination of use of the soft resource by IAB-DU based on whether it will impact co-located MT’s operation.****Observation 2.3:****For multi-parent scenario, it may happen that a soft resource of an IAB-DU cell is explicitly indicated as available by one parent via DCI2\_5 but not by another parent node, and there can be ambiguity in Rel-16 for interpretation of IAB-node’s behaviour on implicit determination in this case.****Proposal 2.3:****In Rel17, the implicit determination of soft resources shall be clarified as follows:*** **If a soft resource of an IAB-DU cell is not explicitly indicated as “available” by a DCI2\_5 associated with a parent node, IAB-DU can use this soft resource if its usage does not impact to MT’s operation over the cell group associated with this parent node without explicit indication.**
 |
| NTT DOCOMO (R1-2101628) | **Proposal9: To support TDM resource multiplexing in DC scenario, following methods can be considered:*** **Option1: DU H/S/NA resource types are configured per DU serving cell with reusing Rel-16 mechanism of DU H/S/NA resource configuration. 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.**

**Proposal10: For intra-band DC scenario, further consider following options for slot format indication.*** **Option1: UE does not expect dynamic indication of slot format for both MCG and SCG. Slot format for both MCG and SCG are semi-statically configured by IAB-donor.**
* **Option2: UE can be configured to receive dynamic indication of slot format for MCG and SCG. Further study collision handling rules when different link directions are indicated for MCG and SCG.**
 |
| Ericsson (R1-2101695, 2101697) | [Proposal 16 For inter-carrier (inter-band and intra-band) DC, the donor-CU can be made aware of the IAB-MT’s capability regarding simultaneous transmission and reception on multiple serving cells in a frequency band, configured by two parent nodes.](#_Toc61903489)[Proposal 17 If an IAB-MT is not capable of simultaneous transmission and reception on any pair of the multiple serving cells in the frequency band configured for two parent nodes, the IAB-MT can assume all serving cells configured for the two parent nodes have aligned UL/DL directions.](#_Toc61903490) [FFS: the IAB-MT’s assumption of aligned UL/DL directions in inter-band and intra-band DC.](#_Toc61903491) [FFS: the IAB-MT’s behavior to handle the configuration conflict.](#_Toc61903492)[Proposal 18 A parent-node can be made aware of the DU resource configuration of the other peer parent node that connects to the same IAB node.](#_Toc61903493)[Proposal 19 Consider Multi-MT as an alternative to enable intra-carrier multi-parent operation for enhanced IAB.](#_Toc61903494)1. Send LS response to RAN3, stating that Scenario 1 and 2 can be supported for the inter-carrier (inter-band and intra-band) case, as long as RAN2/3 ensures that
	1. all resource configurations can be coordinated between parent and child links that operate in same bands, and
	2. the UL/DL slot configuration can be coordinated between parent links in case of intra-band, inter-carrier simultaneous connectivity, which does not require additional specification by RAN1.
 |

**ISSUE 3.1: RAN3 LS RESPONSE**

**FL Proposal 3.1.1: Send LS response to RAN3 that both inter-donor multi-parent scenarios (Scenario 1 and Scenario 2) can be supported in Rel-17 with a specification support for inter-donor resource coordination (e.g. DU H/S/NA and DL/UL resource configurations).**

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

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **ETRI** | **Yes (with comments)** | **We think RAN3 is well aware of resource coordination already, since RAN3 have handled it by themselves. If companies would like to provide more details, we prefer the following ones:***When one IAB node is simultaneously connected to two parent nodes belonging to two different donors, the following cases are feasible from RAN1 point of view:** *Inter-carrier, inter-band DC without any RAN1 specification impact.*
* *Inter-carrier, intra-band DC at least in FR2 without any RAN1 specification impact, if two parent nodes have aligned TDD UL/DL configurations*
* *Inter-carrier, intra-band DC in FR1 can be further discussed in RAN1*
* *Intra-carrier, intra-band DC can be further discussed in RAN1*
 |
| **Ericsson** | **Yes** |  |

**Agreement**

Send LS response to RAN3 that both inter-donor multi-parent scenarios (Scenario 1 and Scenario 2) can be supported in Rel-17 with support for inter-donor resource coordination (e.g. DU H/S/NA and DL/UL resource configurations) in RAN3 specification.

* The reply LS to R1-210004 (RAN3) is endorsed in R1-210XXXX.

**ISSUE 3.2: INTER-CARRIER SCENARIOS**

**FL Proposal 3.2.1: The following are considered to support inter-carrier scenarios in Rel-17:**

* **Solutions to address resource coordination/scheduling collision issues between parent nodes including TDD configurations/slot format indications**
	+ **May consider Rel-16 CA framework as starting point**
* **Signaling to inform parent IAB nodes of soft resource availability**
* **Per-backhaul link resource configurations**
* **Restrictions on simultaneous operation and/or multiplexing capability**
* **Coordination with RAN4 and RAN2 on at least the following aspects:**
	+ **E.g. adding band configuration and RRM requirements for intra-band inter-carrier NR-DC**
	+ **E.g. Updating related UE/MT capabilities for NR-DC so that they are applicable for intra-band inter-carrier NR-DC**

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

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **ETRI** | **No.** | **It seems that the proposed options are highly correlated with the future outcomes from section 2. We do not prefer to have duplicated discussions.** |
| **Ericsson** | **Yes** | We don’t think all of the bullets are needed but can agree to study it further. |
| **Nokia** | **Partly.** | Would be good to separate the discussion for intra-donor and inter-donor. Or is this proposal for intra-donor?* If it is intra-CU, the first sub-bullet seems ok mainly for SFIs.
* The second sub-bullet is not clear to us. Parent does not have to wait for child to indicate soft resource availability.
* The third sub-bullet: Support

The last two sub-bullets may not be needed at this point.  |

**FL Proposal 3.2.2:**

The following are considered to support inter-band/intra-band inter-carrier scenarios in Rel-17:

* Solutions to address resource coordination/scheduling collision issues between parent nodes including TDD configurations, slot format indications, and resource type indications
	+ Consider Rel-16 CA framework as starting point
	+ Per-backhaul link resource configurations in addition to per-DU resource configurations
	+ FFS: Whether or not separate solutions are required for resource coordination in case of inter-CU and intra-CU
* FFS: Enhancements to indication of soft resource availability
* FFS: Additional restrictions on simultaneous operation and/or multiplexing capability in case of inter-band/intra-band inter-carrier DC operation
* From a RAN1 perspective, coordination with RAN4 and RAN2 is expected on at least the following aspects:
	+ Adding band configuration and RRM requirements for intra-band inter-carrier NR-DC
	+ Updating related UE/MT capabilities for NR-DC so that they are applicable for intra-band inter-carrier NR-DC

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

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **Intel** | **Yes** | We generally agree the FL proposal. Regarding the second bullet, since it is only one possible solution to the issue of DCI 2\_5 in DC scenario, we suggest modifying it as: * Solutions to address DCI format 2\_5 in DC scenario
 |
| **Qualcomm** | Yes. | None. |
| **Samsung** | Yes for inter-band, no for intra-band | RAN1 agreed that 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 think we should focus on solutions for supporting inter-carrier inter-band. So, if the intention is to discuss solution for the dual-connectivity scenario, we’d like to suggest to remove “intra-band” in the main bullet and make the last sub-bullet as FFS.  |
| **NTT Docomo** | Yes  | None.  |
| **vivo** | Yes |  |
| **Lenovo, Motorola Mobility** | Yes |  |
| **ZTE, Sanechips** | Partly | We are OK to further discuss this topic.For non-ideal backhaul, only semi-static resource coordination between parent nodes is feasible, so we suggest to remove ‘slot format indications’ from the first sub-bullet. |
| **Huawei** | **Partially** | It will be better to separate the inter-band and intra-band case. In current specification, the simultaneous Rx/Tx capability ***simultaneousRxTxInterBandCA***is defined for inter-carrier CA case and the half-duplex capabilities ***half-DuplexTDD-CA-SameSCS-r16*** is also for inter-band TDD CA***.*** For intra-band CA, we believe that only same TDD configurations are considered. It is still unclear we can actually support simultaneous Rx/Tx within a band. Therefore, we agree with Samsung’s suggestion to focus on inter-band first and put FFS for intra-band case.TS 38.306***simultaneousRxTxInterBandCA***Indicates whether the UE supports simultaneous transmission and reception in TDD-TDD and TDD-FDD inter-band NR CA. It is mandatory for certain TDD-FDD and TDD-TDD band combinations defined in TS 38.101-1 [2], TS 38.101-2 [3] and TS 38.101-3 [4].***half-DuplexTDD-CA-SameSCS-r16***Indicates whether the UE supports directional collision handling between reference and other cell(s) for half-duplex operation in TDD CA with same SCS. The UE can include this field, only if *simultaneousRxTxInterBandCA* is not present. |
| **LG** | Partly | We agree the FL proposal in general.We want to clarify the meaning of ‘Per-backhaul link resource configurations in addition to per-DU resource configurations’. If it means child-link specific DU configuration, it seems not related to solutions to address resource coordination/scheduling confliction issue btw parent nodes. |
| **Ericsson** | Yes | See previous comments above. |
| **CEWiT** | Yes | None |

**Proposed agreement:**

The following are considered to support at least inter-band inter-carrier scenarios in Rel-17:

* Solutions to address resource coordination/scheduling collision issues between parent nodes including TDD configurations, slot format indications, and resource type indications
	+ Consider Rel-16 CA framework as starting point
	+ Solutions for scheduling collision between two parent DUs due to indication of the resource availability for soft symbol(s) to the IAB-DU(s) by DCI format 2\_5
	+ FFS: Whether or not separate solutions are required for resource coordination in case of inter-CU and intra-CU
* Per-backhaul link resource configurations in addition to per-DU resource configurations
* FFS: Enhancements to indication of soft resource availability from child node to parent node(s)
* FFS: Additional restrictions on simultaneous operation and/or multiplexing
* FFS: Whether the above solutions are applicable for intra-band inter-carrier scenarios and whether additional solutions are required (e.g. RAN2 and RAN4 work related to adding band configuration and RRM requirements for intra-band inter-carrier NR-DC or updating related UE/MT capabilities for NR-DC so that they are applicable for intra-band inter-carrier NR-DC)

**Agreement**

The following are considered to support at least inter-band inter-carrier scenarios in Rel-17:

* Solutions to address resource coordination/scheduling collision issues between parent nodes including TDD configurations and resource type indications at least in case of intra-donor CU multi-parent scenarios
	+ Consider Rel-16 CA framework as starting point
	+ Solutions for scheduling collision between two parent DUs due to indication of the resource availability for soft symbol(s) to the IAB-DU(s) by DCI format 2\_5
	+ Solutions for scheduling collision between two parent DUs due to indication of the slot format by DCI format 2\_0
	+ FFS: Whether or not separate solutions are required for resource coordination in case of inter-donor CU multi-parent scenarios
* Per-backhaul link (e.g. per child IAB-MT link) resource configurations in addition to per-DU resource configurations
* FFS: Enhancements to indication of soft resource availability from child node to parent node(s)
* FFS: Additional restrictions on simultaneous operation and/or multiplexing
* FFS: Whether the above solutions are also applicable for intra-band inter-carrier scenarios and whether additional solutions are required (e.g. RAN2 and RAN4 work related to adding band configuration and RRM requirements for intra-band inter-carrier NR-DC or updating related UE/MT capabilities for NR-DC so that they are applicable for intra-band inter-carrier NR-DC)

**ISSUE 3.3: INTRA-CARRIER SCENARIOS**

**FL Proposal 3.3.1: The following are considered to support intra-carrier scenarios in Rel-17:**

* **Intra-carrier DC to the extent that solutions for inter-carrier DC are reused or via implementation (no RAN1 enhancements in Rel-17)**
* **IAB-MT support for multi-DCI based multi-TRP transmission schemes**
* **Multi-MT operation (if supported in RAN2/RAN3)**

**Discussion: Do you support proposal 3.3.1?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **Ericsson** | **Yes to Multi-MT**, no to others | We can support Multi-MT operation but are not willing to support any other intra-carrier scenarios.Multi-MT has less requirements for parent node coordination and synchronization and is, hence, really the only practically feasible alternative among the three. |
| **Nokia** | **Yes** | Support |
| **AT&T** | **Yes** | These options reuse existing solutions or rely on implementation to handle the physical layer coordination required and therefore do not additionally impact RAN1. Note that there was a clear operator request to not preclude intra-carrier operation altogether from Rel-17 since it is a practical scenario for IAB deployments. |
| **Intel** | **Yes to Multi-MT**, no to others | We agree with Ericsson’s comments.  |
| **Qualcomm** | Yes. | None. |
| **Samsung** | No | Main bullet was discussed during RAN plenary as well as WGs and there was no consensus. Also, in RAN plenary, technical concern/issues for RAN1 as well as other WGs were identified compared to inter-carrier DC. In this perspective, we have the following comments for each sub-bullet.In the first sub-bullet, it is difficult for us to understand how intra-carrier DC can be operated or how to reuse solution for inter-carrier DC given many features (coordination, timing requirement, DCI format 2\_0 or 2\_5 collision, UL transmission, Power control and etc.) necessary for intra-carrier DC compared to inter-carrier DC were identified in the plenary. Furthermore, regarding implementation in the first sub-bullet, we don't think such proposal has a point to be captured if it can be solely up to implementation.In the second bullet, we don't think multi-TRP is in the WID scope for IAB. If proponent think Rel-17 multi-TRP operation can be applied for IAB MT as it is, no need to have such proposal because IAB MT inherit access UE procedure. In the third sub-bullet, RAN1 didn't discuss multi-MT operation so far including spec. impacts and benefits from multi-MT. Also, we don't understand how multi-MT operation is related to intra-carrier DC. |
| **NTT Docomo** | Yes  | Agree with Ericsson that multi-MT has less impact for coordination. |
| **vivo** | Yes |  |
| **Lenovo, Motorola Mobility** | Yes, with comments | We support intra-carrier DC at least to the extent that inter-carrier solutions are reused. We support this FL proposal as an FFS and we understand that the list is not exclusive. |
| **ZTE, Sanechips** | No | Agree with Samsung’s comments.Neither Multi-TRP nor multi-MT is one of the DC scenarios defined by RAN2/RAN3. We should focus on the scope in the WID.* + *Support for dual-connectivity scenarios defined by RAN2/RAN3 in the context of topology redundancy for improved robustness and load balancing.*
 |
| **Huawei**  | No | We can spend more time on this but we don’t think any consensus can be achieved. For multi-MT case, it is clearly not in the scope of the WID. |
| **LG** | No | Same opinion with ZTE |
| **CEWiT** | Yes | None |

**ISSUE 3.4: DCI FORMAT 2\_5 FROM MULTIPLE PARENTS**

**FL Proposal 3.4.1: Consider the following solutions for scheduling collision between two parent DUs due to indication of the resource availability for soft symbol(s) to the IAB-DU(s) by DCI format 2\_5:**

* **Alt 1. Existing Rel-16 solution (left to IAB node implementation): The Rel-16 behavior for explicit indication of soft time domain resources by DCI Format 2\_5 is reused for multi-parent scenarios in Rel-17 without additional enhancements.**
* **Alt 2. IAB-MT error case: An IAB node is not expected to receive two DCI format 2\_5 from MCG and SCG indicating the resource availability for a same IAB-DU soft symbol in [Rel-16/]Rel-17.**
* **Alt. 3. Aligned parent nodes: In Rel-17, the IAB-DU may use a soft symbol if the IAB-MT detects both DCI format 2\_5 with an AI index field value indicating the soft symbol as available.**
	+ **FFS parent coordination required**
* **Alt 4. Independent parent nodes: In Rel-17, the indication of availability of soft resources via DCI format 2-5 from a parent node is only valid for the IAB-DU cell(s) which uses the same carrier(s) in the backhaul link for the same parent.**

**Discussion: Do you support proposal 3.4.1?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments**  |
| **ETRI** | **No** | **This proposal is also highly correlated with the on-going discussions. When we don’t know the high-level design of resource type configuration/indication for Rel-17 yet, how can we discuss further details for DC scenarios?****At this stage, we prefer Alt. 1. (In case that we have to choose one for some reasons.)** |
| **Ericsson** | **Yes** | Only Alt. 3 and Alt. 4 take into consideration the existing agreement (RAN1 #98) that H/S/NA configuration is per {MT CC, DU cell}.We prefer Alt. 3 since it is slightly more general than Alt. 4. |
| **Nokia** | **Yes, partly** | Need some clarification on Alt.1/Alt.2/Alt.3 on how this actually enable DC operation. Support Alt. 4 as that seems to be clear. |
| **AT&T** | **Yes, Alt. 4** |  |
| **Intel** | **Yes** | We support the FL proposal. |
| **Qualcomm** | **Partly** | For DC, there are the following cases for a DU resource:* Case1: This DU resource is configured as soft for both parents in terms of (MT CC, DU cell), and explicit indications of availability are detected from both parent.
* Case2: This DU resource is configured as soft for both parents in terms of (MT CC, DU cell), and explicit indication of availability is detected from one parent but not from the other parent.
* Case3: This DU resource is configured as soft for both parents in terms of (MT CC, DU cell), and explicit indication of availability is not detected from either parent.
* Case4: This DU resource is configured soft for one parent but not for another parent in terms of (MT CC, DU cell).

Existing Rel16 solution can be applied directly for case3&4, but some extension or clarification on IAB-node behavior needs to be addressed for case1&2.Alt3 addressed case1 but not case2. We suggest to enhance Alt3 with following clarification on implicit determination to cover case2, e.g. “IAB-DU may use the soft resource if the usage does not impact IAB-MT’s TX/RX on the cell group associated with the parent node from which explicit availability is not indicated ”. Alt4 does not cover the case that DU cell is partially overlapping with carriers of MT from two parents, e.g. A DU cell can be configured with a carrier whose bandwidth overlaps with MT CC1 from parent1 and MT CC2 from parent2. |
| **Samsung** | **Alt.1 for Rel-16. FFS for Rel-17** | Case 1 classified by QC: As several companies brought up in email discussion for Rel-16 IAB, it can be already addressed by Rel-16 spec. "each of the more than one DCI formats 2\_5 indicates a same value for the availability combination of the soft symbols in the slot". In addition, there may be implementation such as slow coordination between parent nodes to avoid simultaneous TX of DCI format 2\_5. Case 2: Maybe, it would be good to clarify what the issue is for our understanding. On the other hand, there may be implementation such as avoiding soft resource configuration for both parent DUs in the same time.Overall, we don't want to have specification impacts for Rel-16 given now is very late stage for Rel-16 and then we'd like to focus on Rel-17. For Rel-17, we are open to discuss which alternative is a best way. |
| **NTT Docomo** | **Partly**  | Agree with Qualcomm’s comments. Suggest to include implicit indication in alt.3. e.g.**Alt.3. In Rel-17, the IAB-DU may use a soft symbol if the IAB-MT is explicitly indicated or implicit determined the soft symbol as available from both parent nodes.** |
| **vivo** | **Yes**  | Only Alt2/3 can be further considered. Alt4 cannot address all the conflict case. The TDM/non-TDM multiplexing capability is per cell pair {DU cell, MT cell}, even DU and MT use different carrier, inter-cell impact still exist. |
| **Lenovo, Motorola Mobility** | **Partly** | We support addressing the problem, but the list of solutions is not complete. For example, the IAB-MT may receive one or two DCI 2\_5 from one or two parent nodes, and perform AND on the two AI, or prioritize between AI from MCG and SCG, etc. Practical for reliability scenarios. |
| **ZTE, Sanechips** | **Partly, Alt 1 or Alt 2** | For inter-carrier DC, the motivation to indicate the availability of a same DU resource from both parents is not clear, Alt 2 is slightly preferred.  |
| **Huawei** | **Partially**  | We support to adopt Alt.2 for Rel-16 since only Inter-band inter-carrier DC is possible. For Rel-17, Alt.3 can be considered. Case 2 mentioned by QC is mixed case and can be solved by combining the explicit and implicit determination of the resource availability.  |
| **LG** | **Partly** | In our view, the availability indication of a DU-cell is indicated from one parent-node.For instance, MT-CC1 receives the availability indication for DU-cell 1 from parent node1 and MT-CC2 receives the availability indication for DU-cell2 from parent node2.In this case, if the multiplexing capability for {DU-cell1, MT-CC2} is no-TDM, Alt 4 can be applied so DU-cell1 operation can be determined by the availability indication for DU-cell1 only.On the other hand, if the multiplexing capability for {DU-cell1, MT-CC2} is TDM, Alt 3 should be applied. Then, DU-cell1 operation is determined based on both of the availability indication for DU-cell1 and DU-cell 2. |
| **CEWiT** | **Partly** | IAB-MT behavior after detecting 2 DCI format 2\_5 is defined in Rel. 16 as*“The IAB-node MT detects more than one DCI formats 2\_5 indicating an availability combination of soft symbols in a slot, the IAB-node MT expects that each of the more than one DCI formats 2\_5 indicates a same value for the availability combination of the soft symbols in the slot”*This may not hold good in case of multiparent scenario, where each parent node independently indicates availability value. Therefore, reuse of Rel. 16 mechanism without modification (Alt 1) may not work in case of IAB multiparent scenario.If IAB-DU is configured as S both parents in terms of (MT CC, DU cell), then IA is needed from both parent nodes, and that precludes Alt 2. We support Alt 3 with modification* Alt 3 is not considering the implicit IA. Explicit IA from both parents is not mandatory for IAB-DU to use soft resource. IAB-DU can use the soft resource if it derives implicit IA. We suggest to add implicit condition to Alt3.
 |