**3GPP TSG RAN WG1 #102-e R1-20xxxxx**

**e-Meeting, August 17th – 28th, 2020**

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

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

**Title: Summary of [102-e-NR-eIAB-01]**

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

# Introduction

This contribution provides a summary of the following email discussion:

[102-e-NR-eIAB-01] Email discussion on enhancements to resource multiplexing between child and parent links of an IAB node by 8/28 – Thomas (AT&T)

* Prioritize topics to be resolved in RAN1#102-e by 8/19

# Simultaneous Operation of Access and Backhaul Links

## Definition of Rel-17 Multiplexing Scenarios (High priority):

**Goal:** Confirm which scenarios are the focus for Rel-17 and describe key attributes of the scenarios which are relevant for RAN1 (e.g. FR1 vs. FR2, in-band/out-of-band, TDD spectrum considerations such as RAN4 Scenarios 1/2, high-level antenna designs/RF architectures, deployment considerations etc.)

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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| --- | --- |
| **ZTE (R1-2005467)** | ***Proposal 2: To de-prioritize simultaneous DU-Tx/MT-Rx, DU-Rx/MT-Tx and DU-Tx/MT-Tx in RAN1 Rel-17 normative work.***   * ***The above three duplex operations can still be implemented in practice, e.g., by using multi-panel antenna and separate PA to isolate the DU-Tx/Rx and MT-Tx/Rx in their analog forms. In this case, there is no FDM/SDM relation in between per RAN1 perspective.*** |
| **CEWiT (R1-2006329)** | **Observation 1:** An IAB node can have TDM, FDM, FDM with HDC, SDM, SDM with HDC and IBFD multiplexing capabilities and can support TDM, DUTx-MTTx, DURx-MTRx, DURx-MTTx and DUTx-MTRx modes of operation |
| **ETRI (R1-2006361)** | ***Observation 1:*** Unless a feasible solution for intra-node interference suppression/cancellation is identified, support of MT-TX/DU-RX or MT-RX/DU-TX with two non-overlapping frequency channel allocations should be prioritized rather than the fully or partially overlapping frequency channel allocation.  ***Observation 2:*** In paired spectrum case, the best configuration of MT-TX/DU-TX and MT-RX/DU-RX is the same as the best configuration of MT-TX/DU-RX and MT-RX/DU-TX.  ***Proposal 1:*** For MT-TX/DU-RX and MT-RX/DU-TX in paired spectrum, we propose considering the configuration of an IAB node in which the opposite directions of the parent and child nodes use the same frequency bands and discussing the relevant specification impacts.  ***Proposal 2:*** We propose studying the support of MT-TX/DU-TX and MT-RX/DU-RX with fully-overlapping frequency band and the feasibility and specification impact including necessary interference management mechanisms and a new timing advance at the child node.  ***Proposal 3:*** It is proposed that the resource multiplexing configurations other than “MT-TX/DU-RX and MT-RX/DU-TX in unpaired spectrum” be considered as higher priority. |
| **LG (R1-2006382)** | ***Proposal 1: To support simultaneous operation of MT and DU, co-located inter-panel operation and intra-panel operation should be considered.*** |
| **Ericsson (R1-2006903)** | Proposal 1 Simultaneous transmission based on FDM/SDM principles, i.e., *half-duplex transmission*, and simultaneous reception based on FDM/SDM principles, i.e., *half-duplex reception,* are technically feasible and should be RAN 1’s priority in Rel-17.  Proposal 2 Simultaneous MT RX and DU TX, i.e., *downstream full-duplex*, and simultaneous MT TX and DU RX, i.e., *upstream full-duplex*, are not prioritized in Rel-17.  Proposal 3 RAN4 IAB Scenario 2 is adopted as the baseline for IAB simultaneous-operation discussion.  Proposal 4 RAN1 to exclude simultaneous-operation discussion for the case when an IAB-node simultaneously receives from the parent IAB-DU and from a served UE. |

The four main multiplexing scenarios from the Rel-17 WID are (also based on the no-TDM multiplexing capabilities):

**Case 1: Simultaneous MT-Tx/DU-Tx**

**Case 2: Simultaneous MT-Rx/DU-Rx**

**Case 3: Simultaneous MT-Rx/DU-Tx**

**Case 4: Simultaneous MT-Tx/DU-Rx**

Companies have suggested that whether a given case is supported/prioritized depends on additional considerations such as spectrum type, frequency allocation, deployment considerations etc. As a first step, the different cases should be mapped to these factors based on the level of prioritization: high/low/excluded from Rel-17. (Note that low priority in this context means that the scenario is supported but potentially with only limited specification effort.)

**Question 2.1.1: Unpaired Spectrum**

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| --- | --- | --- | --- |
| Company | Prioritization/support in Rel-17 | | |
| High Priority | Low Priority | Exclude |
| AT&T | Case 1, Case 2, Case 3, Case 4 |  |  |
| Huawei | Case 1, Case 2, Case 3, Case 4 |  |  |
| Ericsson | Case 1, Case 2 |  | Case 3, Case 4 (unless a quantitative proof of concept is provided, accounting for that the channel is part of the isolation problem) |
| Nokia | Case 1, Case 2 |  | Case 3, Case 4 |
| Intel | Case 1, Case 2 |  | Case 3, Case 4 |
| ZTE, Sanechips | Case 2 | Case 1 (w/o support of case-6 timing) | Case 3, Case 4. (Exclusion is per specification wise. Both cases are still possible in implementation in case the isolation problem is gone. ) |

**Question 2.1.2: Paired Spectrum**

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| Company | Prioritization/support in Rel-17 | | |
| High Priority | Low Priority | Exclude |
| AT&T | Case 3, Case 4 | Case 1, Case 2 |  |
| Huawei | Case 1, Case 2 | Case 3, Case 4 |  |
| Ericsson |  | Case 1, Case 2 (is simultaneous DL/UL in paired spectrum not already covered?) | Case 3, Case 4 (same problem as for unpaired spectrum) |
| Nokia |  | Case 1, Case 2 | Case 3, Case 4 |
| Intel | Case 1, Case 2 | Case 3, Case 4 |  |
| ZTE, Sanechips |  | Case 2, Case 1 (w/o support of case-6 timing) | Case 3, Case 4.  (same consideration as in Q2.1.1) |

**Question 2.1.3: FR1 bands**

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| --- | --- | --- | --- |
| Company | Prioritization/support in Rel-17 | | |
| High Priority | Low Priority | Exclude |
| AT&T |  | Case 1, Case 2 | Case 3, Case 4 |
| Huawei | Case 1, Case 2 | Case 3, Case 4 |  |
| Ericsson |  | Case 1, Case 2 (only relevant for TDD and there are only 1 or 2 TDD bands in FR1) | Case 3, Case 4 |
| Nokia |  | Case 1, Case 2 | Case 3, Case 4 |
| ZTE, Sanechips | Case 2 (TDD) | Case 2 (FDD), Case 1 (w/o support of case-6 timing) | Case 3, Case 4.  (same consideration as in Q2.1.1) |

**Question 2.1.4: FR2 bands**

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| Company | Prioritization/support in Rel-17 | | |
| High Priority | Low Priority | Exclude |
| AT&T | Case 1, Case 2, Case 3, Case 4 |  |  |
| Huawei | Case 1, Case 2, Case 3, Case 4 |  |  |
| Ericsson | Case 1, Case 2 |  | Case 3, Case 4 (same problem as for unpaired spectrum) |
| Nokia | Case 1, Case 2 | Case 3, Case 4 |  |
| ZTE, Sanechips | Case 2 (always TDD in FR2) | Case 1 (w/o support of case-6 timing) | Case 3, Case 4.  (same consideration as in Q2.1.1) |

Comments on prioritization of cases

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| --- | --- |
| **Company** | **Comments** |
| Huawei | The reason why we propose to put low priority to case 3/4 for paired spectrum and FR1 is that it may be difficult to implement full duplex in lower frequency band when MT and DU are on the same panel. However, we do not no need to exclude any case at the current stage. |
| Intel | We want to further clarify/confirm our understanding on those factors for the four simultaneous cases.   * Paired/Unpaired spectrum are usually used to describe per-link DL/UL transmission; now it is used to describe per-node parent BH and child BH transmission. * FR1/FR2: Does FR1 mean parent BH and child BH both in FR1? Also, FR2 means parent BH and child BH both in FR2? Then, do we need another case of FR1/FR2 combination? |
| ZTE, Sanechips | We de-prioritize simultaneous Tx mainly because case 6 timing has several problems regarding to limitation upon performance (e.g., dedicate DU slots on a per child link basis) and complexity in specification (e.g., potential impact to case-1 timing and new RAN4 requirement for UL-Tx timing). |

## Key requirements/issues for Rel-17 Multiplexing Scenarios (Med priority):

**Goal:**  Identify and describe key performance metrics and targets for prioritized multiplexing scenarios (e.g. latency reduction, system capacity improvement, etc.) as well as issues which may limit the benefits or impact feasibility, including the impact on non-IAB networks.

**Summary of input contributions:**

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| **Huawei (R1-2005260)** | ***Observation 1:*** *The capabilities for simultaneous operations can be categorized into two types:*   * *Unrestricted capabilities of simultaneous operations: IAB node can implement simultaneous operations without restriction* * *Restricted capabilities of simultaneous operations: IAB node can implement simultaneous operations only if some conditions are met*   ***Observation 2:*** *Based on the type of the capabilities for simultaneous operations, IAB node and its parent node can determine the modes of simultaneous operations, which include:*   * *Mode 1: The IAB node can implement simultaneous operation in both hard and soft resources* * *Mode 2: The IAB node can implement simultaneous operation only in soft resources based on the dynamic scheduling and indication from parent node*   ***Proposal 4:*** *To determine the simultaneous operation mode of an IAB node, the parent node should be aware of the type of simultaneous operation capabilities of the IAB node.* |
| **Vivo (R1-2005399)** | ***Observation 1: When a certain duplexing operation is adopted at a given time, parent node and child node need to take corresponding actions mutually based on the duplexing operation, e.g., cooperative power control, cooperative resource scheduling, etc.*** |
| **ZTE (R1-2005467)** | ***Observation 1: For simultaneous DU-Tx/MT-Rx and simultaneous DU-Rx/MT-Tx, although RAN4 may need to work on the corresponding requirements (up to RAN4), the two full-duplex operations can be considered as implementation issues from RAN1 perspective.*** |
| **Intel (R1-2005893)** | **Observation 1:** For the simultaneous operations of IAB-node’s child and parent links:   * MT RX/DU RX: With slot alignment, the child MT needs to know the parent backhaul propagation delay , which needs additional signaling. * MT RX/DU TX: Slot alignment scheme is not possible and cannot be supported. * MT RX/DU RX: There are two ways to fulfill with slot alignment scheme and in one of the two ways, the child MT needs to know the parent backhaul propagation delay and the parent timing advance parameter , which needs additional signaling.   **Proposal 1:** For simultaneous operation of IAB-node’s child and parent links, w/o slot alignment scheme is preferred. No additional timing adjustment is needed and current TA control mechanism, timing relationship between parent IAB node, IAB node and its child node can be remained.  **Proposal 2:** When one of the SDM/FDM multiplexing mode (MT Tx/DU Tx, MT Tx/DU Rx, MT Rx/DU Tx, MT Rx/DU Rx) is supported, the corresponding transition guard symbols (desired and provided) are not needed, as summarized in Table 1. |
| **Samsung (R1-2006165)** | ***Observation 1: There is no need for further specification support in terms of resource configuration in Rel-17 IAB in order to support simultaneous operation in child and parent link.***  ***Observation 2: Without sufficient interference handling between the parent and child link for Case#3 and Case#4, simultaneous operation is not feasible.***  ***Observation 3: For Case#3 and Case#4, physical isolation of DU and MT antennas could contribute in interference handling. However, physical isolation alone might not be enough and additional mechanisms could be necessary.***  ***Observation 4: Without proper time alignment of child link and parent link, ISI/ICI could obstruct frequency domain processing.***  ***Proposal 1: For simultaneous operations of an IAB node with benefits of spectral efficiency and latency, RAN1 should provide spec. supports to allow efficient operations considering implementation limitations such as near-field channel estimation for interference handling.*** |
| **CEWiT (R1-2006329)** | **Observation 2:** The multiplexing capability and the supported modes of operation of the child node are crucial information required at donor and parent nodes to configure resources to child node efficiently.  **Observation 3:** Resource allocation of IAB-MT and IAB-DU are important factor in determining the active mode of operation of the IAB node  **Observation 4:** The active mode of operation of an IAB node depends on the capability and supported modes of operation of the IAB node, resource configuration of IAB-MT and IAB-DU, capability and active mode of operation of the parent node and the network conditions  **Observation 5:** Multiplexing capability information of parent might be useful to the child in certain cases. |
| **LG (R1-2006382)** | ***Proposal 4: For an IAB-node, simultaneous and non-simultaneous operation can be transited in implicit or explicit manner.*** |
| **Qualcomm (R1-2006825)** | **Observation 1:**  **For improved system performance the IAB-DU resource configurations for a pair of parent and child IAB-nodes need to be commensurate with the duplexing capability of the child IAB-node.**  **Observation 2:**  **The Rel-16 framework for is already suitable to support efficient semi-static IAB-DU resource configuration as a function of duplexing capabilities of IAB-nodes.**  **Observation 3:**  **Duplexing capability is in general conditional and not necessarily an absolute property that applies independently of the IAB-MT and IAB-DU beams direction and shape.** |
| **Ericsson (R1-2006903)** | Observation 1 Simultaneous TX/RX of an IAB-node is not feasible in RAN4 IAB Scenario 1 where the IAB-MT transmits in UL slots while the IAB-DU transmits in DL slots and the IAB-MT receives in DL slots while the IAB-DU receives in UL slots.  Observation 2 For an {MT CC, DU cell} pair where the IAB-node is indicated *no-TDM* capable, DU time-domain resources are implicitly *Soft* with respect to the corresponding MT CC. |

Many factors have been listed as impacting the potential performance/feasibility of the different cases described in Section 2.1. These include:

* Antenna design (same panel or multi-panel operation)
* Cross-link and self-interference limitations (R1-2006165):

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| **Simultaneous operations** |
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* Need for power control at IAB-DU as well as IAB-MT
* Inclusion of exclusion of access (UE) and backhaul (child/parent) links
* Inclusion or exclusion of control vs. data signals/channels
* Timing alignment requirements (figures from R1-2005893):

A screenshot of a cell phone

Description automatically generatedA screenshot of a cell phone

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MT TX/DU TX MT RX/DU RX

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MT RX/DU TX MT TX/DU RX

* Static vs. dynamic determination of IAB-node multiplexing capability
* DL/UL spectrum operation (i.e. RAN4 Scenario 1 vs. Scenario 2 in R1-2006903):

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| --- | --- | --- | --- |
|  |  | **DL** part of TDD pattern | **UL** part of TDD pattern |
| **Scenario 1** | IAB-MT | RX | TX |
| IAB-DU | TX | RX |
| UE | RX | TX |
| **Scenario 2** | IAB-MT | RX or TX |  |
| IAB-DU | RX or TX |  |
| UE | RX | TX |

The relevance and impact of these different factors on the different multiplexing cases should be further considered before moving to discuss potential solutions and enhancements, but as pointed out by different companies, some factors are heavily dependent on IAB node capability, implementation considerations which may be outside the scope of RAN1, or have dependencies on deployment/spectrum regulatory limitations. The table below attempts to capture different factors and highlights their relative impact on the feasibility of a given multiplexing case.

**FL Survey 2.2.1: Do you agree with the following impact table for different multiplexing cases? Are there any additional (high-level) factors which should be considered?**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Antenna/RF front-end impact** | **Interference type** | **Power control** | **Resource partitioning** | **Timing** |
| **Case 1** | N/A | CLI (aggressor) | Existing PC | May impact access UEs DL performance | MT/DU timing alignment possible with Case 6 timing |
| **Case 2** | Intra-panel – Maybe (depending on receiver implementation)  Inter-panel – Maybe (depending on isolation) | CLI (victim) | May be needed if parent link received power >> child link received power | May impact access UEs UL performance (in RAN4 Scenario 1) | MT/DU timing alignment possible with Case 7 timing |
| **Case 3** | Intra-panel – Yes  Inter-panel – Maybe (depending on isolation) | CLI + self-interference | May need to consider self-interference isolation requirements | Consider both access and backhaul links | Timing alignment not possible |
| **Case 4** | Intra-panel – Yes  Inter-panel – Maybe (depending on isolation) | CLI + self-interference | May need to consider self-interference isolation requirements | Consider at least backhaul links  Impact on access links depends on isolation and RAN4 Scenario 1/2 | Timing alignment possible with parent timing advance and backhaul propagation delay known at child |

**Discussion:**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei | Some further clarifications are needed | In general, we think it is helpful to list all some high-level impacting factors for all cases which can be used to have some comparisons and even do further prioritizations on the supported cases. However, some further details may be needed for each of impacting areas. This is not easy task but may be a good guidance for all the companies to prepare further discussions  For case 1, we think it is possible for both intra-panel and Inter-panel case as long as there is sufficient isolation. If the power gap between MT and DU is large, it may also have some RF impact. In this case, power control enhancement may be helpful. And the impact on resource partitioning in the table is not clear to us.  For Case 2, it is not clear what “May impact access UEs UL performance (in RAN4 Scenario 1)“ in the resource partitioning column means here. |
| Ericsson | In general, yes. | We are not convinced that inter-panel is feasible for IAB full duplex since the level of **isolation is at least partly depending on the channel which is outside of the control of the IAB node**. Hence, it will be very difficult to guarantee any isolation between the MT and DU.  Case 1 and Case 2 should be further limited to BH + BH operations in DL, i.e., UL access links are excluded from the simultaneous operation since otherwise legacy UEs may not be able to perform IA/RA. That is, **use RAN4 Scenario 2 as baseline for further discussions for case 1 and Case 2**.  The level of **interference on non-IAB nodes** is highly related to when transmissions take place (UL and/or DL slots). See Fig. 1 in R1-2005261.  **Rel-15 UEs** will be particularly victimized from interference since they **are incompatible with Rel-16 CLI** functionality. This must be particularly considered. |
| Nokia/NSB | Further discussion is needed. | The priority shall be Case 1 and 2. The following input is based on that,  Antenna/RF front-end impact : Don’t see this as an issue for case 1 and case 2 as the TDD constraint will be maintained in this case.  CLI: This we tend to agree as IAB node MT and DU is in Tx for case 1, therefore may create CLI towards other nodes. Case-2 is interference coming from others and not something IAB discussion can handle. We also think that regardless of these cases, CLI can occur between nodes and investigations on coordination mechanism is needed.  Power control: Need further discussion on case-1/2. Case-1 may use NR power control mechanisms, but if we focus on CLI and other aspects, that may not be enough.  Resource partitioning: Resource multiplexing between parent and child links may be needed to address cross link interference.  Timing: Agree with the case-6 and 7 impact. |
| Intel | In general, yes | In general, we think multi-panel operation is more preferred over single-panel operation for simultaneous transmission. Also, we are not sure whether slot-level timing alignment are required for simultaneous transmission. |
| ZTE, Sanechips | Partially agree | **For factor “Antenna/RF front-end impact”:**  We are not sure what “N/A” means for Case 1. It seems simultaneous Tx from DU and MT should have at least one RF architecture impact regarding to whether DU and MT share the same PA or not.  **For factor “Power control”:**  Existing PC may not be able to completely solve the problem of power sharing. In addition, there is no DL power control in current spec.  **For factor “Interference type”:**  A more serious issue of “self-interference” in case 3 an case 4 is that, from baseband receiver processing point of view, either the interfering Tx signal is distorted (due to cap of ADC in case of no AGC) or the interfered Rx signal is somehow distorted (due to severe suppression of ADC in case AGC is used). In other words, the interference signal may not be in compliance with “Tx-constructed” formulation and possibly expand from RB x to RB y.  **For factor “Resource partitioning"**:  We are not sure we understand the intention of whole column.  **For factor “Timing”**:  In case 4, “timing alignment possible with parent timing advance” looks ok in theory but can have serious problem in practice:   * Any (controlled or autonomous) adjustment of UL-Tx timing of an IAB node on i-th hop may lead to adjustments of UL-Tx timing in IAB nodes that are on all follow-up hops. The worse is that these adjustments inside IAB nodes may not be able to well sync-up with each other and it is hard for IAB node and its parent to know when the sync-up is well-done. |

## Solutions/enhancements for Rel-17 Multiplexing Scenarios (Low priority):

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

**Summary of input contributions:**

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| **Huawei (R1-2005260)** | ***Proposal 1:*** *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 2:*** *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 3:*** *Donor CU can provide two sets of resource configurations to each DU cell: a basic resource configuration for access UEs and one additional resource configuration for child IAB node MTs, and the DU cell should maintain two sets of DU resource configurations simultaneously.* |
| **Vivo (R1-2005399)** | ***Proposal 1: Support coordination of time domain resources where a certain duplexing operation is adopted.***   * ***Coordination via CU, and/or,*** * ***Coordination between parent node and child node.***   ***Proposal 2: For resource interference handling in case of FDMed and/or SDMed resource multiplexing, support coordination of frequency domain resources between backhaul link and access link.***  ***Proposal 3: Enhance frequency domain resource configuration to support FDMed and SDMed resource multiplexing between backhaul link and access link.*** |
| **ZTE (R1-2005467)** | ***Proposal 1: The similar semi-static resource partitioning scheme to Rel-16 mechanism of CU time-domain H/S/NA configuration can be the starting point of resource partitioning scheme in frequency domain.*** |
| **Nokia, Nokia Shanghai Bell (R1-2005535)** | **Proposal 2.1: For FDM and SDM operation of the IAB node, the frequency and spatial availability of a resource shall be additionally indicated via semi-static signalling.**  **Proposal 2.2: For FDM operation, a dynamic indication of frequency availability of soft resources shall be controlled by the parent via introducing frequency availability indication.**  **Proposal 2.3: 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 2.4: For FDM/SDM operation, allowed direction of the transmission for the IAB DU in F-S resources may be further controlled by the parent node by using a dynamic indication.** |
| **Intel (R1-2005893)** | **Proposal 3:** For the semi-static DU resource configurations, support additional supplemental per-link configuration. |
| **Lenovo, Motorola Mobility (R1-2005927)** | **Proposal 1:** Extend IAB resource configuration and availability indication to the frequeny domain.  **Proposal 2:** Support early TCI indication by IAB nodes to facilitate SDM. |
| **AT&T (R1-2005951)** | **Proposal 2: Consider specifying support for mechanisms to enable non-TDM STC/SMTC configurations, including overlapping hard and soft configured IAB-DU resources.** |
| **CMCC (R1-2006228)** | **Proposal 1: The symbols of an IAB node MT that are configured to transmit or receive SS/PBCH block, PRACH, and CORESET for Type0-PDCCH CSS set should not be overridden by the slot format provided by the additional *TDD-UL-DL-ConfigDedicated-IAB-MT*.** |
| **CEWiT (R1-2006329)** | **Proposal 1:** IAB node signals its multiplexing capability and supported modes to CU and parent-DU  **Proposal 2:** The following alternatives can be considered in determining active mode of operation of an IAB node  Alt 1: Active mode of operation of IAB node is determined by donor and is explicitly signalled to the parent node  Alt 2: Active mode of operation of IAB node is implicitly derived based on the resource configuration  **Proposal 3:** CU signals H/S/NA to all IAB nodes and it is left to the implementation as to whether use it or not  **Proposal 4:** IAB node derive implicit IA for the S resource when operating in simultaneous Tx and/or Rx mode  **Proposal 5:** Parent signals IA in DCI format 2\_5 for all IAB nodes irrespective of its active mode of operation and the IAB node operating in simultaneous Tx and/or Rx mode Tx/Rx in S resource irrespective of IA  **Proposal 6:** Mechanism to inform parent’s multiplexing capability to child should be supported. |
| **LG (R1-2006382)** | ***Proposal 2: Receiver-side SDM can be applied for at least PDSCH and PUSCH.*** |
| **NTT DOCOMO (R1-2006744)** | **Proposal1: Rel-16 signaling of semi-static configuration of hard/soft/NA resource type for DU symbols and dynamic indication of availability for DU soft symbols should be reused.**  **Proposal2:** **Based on the Rel-16 signaling, 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.**   **Proposal3: On a DU hard/soft-IA flexible symbol, parent node can configure/indicate/schedule IAB node MT Tx or Rx on the symbol, and IAB node DU will perform either Tx or Rx on the symbol based on MT transmission/reception direction and its multiplexing capability.**  **Proposal4: Both semi-static signaling and dynamic indication of frequency resources should be considered to support FDM resource multiplexing.** |
| **Qualcomm (R1-2006825)** | **Proposal 1:**  **IAB-DU semi-static resource configuration for enhanced duplexing capabilities (i.e. simultaneous operation (transmission and/or reception) of IAB-node’s child and parent links) is supported using the existing Rel-16 resource management framework.**  **Proposal 2:**  **Rel-17 includes enhancements for the dynamic nature of the duplexing capability of an IAB-node. Details are FFS.** |
| **Ericsson (R1-2006903)** | Proposal 5 H/S/NA configuration for a given DU time-domain resource is only explicitly provided to the IAB-node/transmission-direction combination which is indicated as TDM required.  Proposal 6 A default resource attribute for the IAB-DU H/S/NA resource configuration is *Soft*.  Proposal 7 Specify a mechanism for frequency-domain resource multiplexing between MT and DU of an IAB-node. |

**FL Proposal 2.3.1: The Rel-16 semi-static and dynamic resource allocation mechanisms are the starting point for supporting Rel-17 multiplexing cases.**

* **At least resources used for simultaneous IAB-DU and IAB-MT PDSCH and/or PUSCH transmission and reception (depending on the supported multiplexing case) can overlap in time when soft resources are configured at the child IAB-DU.**

**Discussion:**

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| **Company** | **Do you agree with FL Proposal 2.3.1?** | **Comments** |
| Huawei | Yes | Agree with the proposal. Simultaneous operation in hard resource are also possible in some cases. One simple example is when there is sufficient isolation between parent link and child link. Another example is when the IAB node MT support case #6 timing then simultaneous Tx (Case 1) can also be possible in hard resources. |
| Ericsson | Big picture, yes | We agree to the principle proposal “The Rel-16 semi-static and dynamic resource allocation mechanisms are the starting point…”.  The implications of the sub-bullet are not clear to us since even if the IAB-DU is configured hard, if the parent node knows the IAB capabilities, the parent node would/could schedule MT |
| Nokia | Yes | Agree with Huawei that hard resources may overlap in time as well. Additionally, allowing resources to overlap in time may be contingent on channel conditions. |
| Intel | Yes |  |
| ZTE, Sanechips | Agree the main proposal, but the sub-bullet is a bit pre-mature at this time. | We prefer to have a basket agreement by covering all resource types (e.g., H/S/NA) together, rather than agreeing something first for the soft resource in the first meeting. |

**FL Proposal 2.3.2: The following categories of enhancements should be further considered to support simultaneous operation of access and backhaul links (not an exhaustive list):**

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

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 2.3.2? Are additional categories missing (at a very high level)** | **Comments** |
| Huawei | Yes | We understand the intention of the list is to provide guidance for further discussion on the potential enhancement. We propose one additional bullet   * Enhancements to IAB node capability signaling with respect to simultaneous operation based on Rel-16 IAB signaling framework, e.g. conditional simultaneous operation. |
| Ericsson | Maybe | We can agree that the listed categories should be studied, but we do not want to commit to specifying aspects that turn out not being needed. We would prefer to have a clear understanding on the high-level scenario assumption before going into technical details of solutions. |
| Nokia | Yes | We would recommend including potential enhancements to beam measurement/reporting necessary for supporting SDM operation. |
| Intel | Yes |  |
| ZTE, Sanechips | Prefer not to treat it as a proposal that needs to end up with an agreement. | The list seems more like a recommendation for the FFS, rather than a solid technical proposal. |

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

## Definition of Dual Connectivity Scenarios (High priority):

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 (R1-2005260)** | ***Proposal 5****: RAN1 needs to clarify the dual connectivity scenario for Rel-17 IAB.* |
| **Nokia (R1-2005535)** | **Observation 3.1. Clarification is needed for IAB-MT DC resource configurations and SDM/FDM operation.** |
| **Qualcomm (R1-2006825)** | **Proposal 3:**  **Rel-17 includes enhancements for efficient IAB-DU resource coordination across links to the multiple parents sharing the same time / frequency resources.** |
| **Ericsson (R1-2006903)** | Proposal 8 RAN1 should discuss whether IAB NR-DC operation using one single carrier (IAB Intra-Carrier NR-DC operation) is in the scope of the Rel-17 IAB WID, or should be considered in a wider scope than IAB. |

Topological redundancy with two parent nodes is already supported in Rel-16. From 38.300: “For IAB-nodes operating in SA-mode, NR DC is used to enable route redundancy in the BH by allowing the IAB-MT to have concurrent BH links with two parent nodes.” From a RAN1 perspective, the key question is whether the parent links share the same time/frequency resources (as well as FR1 vs. FR2 support) as this drives the required level of coordination and impacts resource allocation.

**FL Survey 3.1.1: Should both inter-carrier and intra-carrier DC scenarios for IAB-MTs be considered in Rel-17?**

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| AT&T | Yes | Prioritization for intra-carrier DC scenarios can be made since it is the more limiting scenario (similar to in-band vs. out-of-band operation) |
| Huawei | Yes | The necessity of intra-band DC should be justified, e.g. why it is important in the context of IAB |
| Ericsson | Not now | Inter-carrier DC should be considered for dual-connectivity scenarios.  Before RAN1 starts IAB work on and specification of intra-carrier DC, RAN Plenary should clarify that this is within the scope of the IAB WI. |
| Nokia | Yes | Agree with AT&T, that intra-carrier DC scenarios represent the more relevant scenario for consideration. We do not think there is any special attention needed for inter-band cases. |
| ZTE, Sanechips | No, only inter-carrier DC scenario should be considered in Rel-17 IAB | IAB MT should not go beyond what normal UE can support regarding to intra-carrier DC vs inter-carrier DC. Rel-17 IAB does not seem to have that kind of time budget to step ahead of UE features regarding to normal Uu link operations. |

**FL Survey 3.1.2: Should both FR1 and FR2 bands be considered for DC scenarios in Rel-17?**

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| AT&T | Yes | FR1/FR2 can be considered for inter-carrier DC and FR2 should be prioritized over FR1 for intra-carrier scenarios due to the ability to better isolate the links between different parents |
| Huawei | Yes | Unsure how this have an impact for specification work. |
| Ericsson | Yes | Inter-carrier DC using both FR1 and FR2 should be specified. |
| Nokia | Yes | A similar view as HW, not clear what specification impact is band dependent |
| ZTE, Sanechips | Not sure whether this can be assessed by RAN1 only | DC scenarios are determined by RAN2/3, according to WID.  For the time being, RAN1 can only consider Rel-16 IAB DC scenarios. If Rel-16 IAB DC allows FR1 and FR2, RAN1 should simply follow; otherwise, the decision maybe needed in plenary. |

## Key issues/requirements for Dual Connectivity Scenarios (Med priority):

**Goal:**Identify and describe key performance metrics and targets for prioritized multi-parent scenarios (e.g. reliability or system capacity improvement, etc.) as well as issues which may limit the benefits or impact feasibility.

**Summary of input contributions:**

|  |  |
| --- | --- |
| **Vivo (R1-2005399)** | ***Observation 3: In case of in-band deployment of SCG and MCG, if capability of the IAB-node only supports TDMed operation between DU and MT on the operation band, IAB-node needs to follow resource availability indication from either MCG or SCG.*** |
| **Nokia, Nokia Shanghai Bell (R1-2005535)** | **Observation 3.2. The DU configurations of the parent nodes of a DC connection need to be aligned so that the IAB-MT reception would be well defined.**  **Proposal 3.3: For IAB-MT DU scenario, RAN1 shall investigate the required coordination between parent nodes such that MT reception is well aligned.**  **Proposal 3.4. RAN1 to investigate possible differences in the RX timing of MCG and SCG links causing additional issues when SDM/FDM operation is supported.** |
| **Samsung (R1-2006165)** | ***Proposal 2: As a baseline, consider dual connectivity scenarios with two parent nodes under same IAB-donor in Rel-17.*** |
| **Qualcomm (R1-2006825)** | **Observation 4:**  **From a RAN1 perspective, the impact of multiple-parents scenarios on IAB-DU resource coordination resolves to the need to consider the additional duplexing constraint / capability of an IAB-node across the links to the multiple parents.** |
| **Ericsson (R1-2006903)** | Observation 3 IAB Inter-Carrier NR-DC is already supported with Rel-16 specification. For independent carriers, resource coordination is not needed. |

Especially for intra-carrier DC scenarios, several companies have suggested that the DC scenarios cannot be considered independently of the supported multiplexing scenarios (TDM + no-TDM Case 1-4)

**FL Survey 3.2.1: Can different DC scenarios be considered independently from the multiplexing cases? If the answer is no, which multiplexing cases (TDM + no-TDM Case 1-4) should be considered for different DC scenarios?**

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| AT&T | Yes | All multiplexing cases should be applicable for both inter- an intra-carrier DC scenarios. However for intra-carrier DC, the level of optimization for the no-TDM cases should be further considered vs. the potential specification impact/implementation complexity |
| Huawei | Yes | There is no need to preclude the combination of DC and simultaneous operation between parent and child links at the current stage. However it may be more important to clarify whether intra-band DC should be supported in the first place. |
| Ericsson | No | DC scenarios assuming TDM should be prioritized since TDM based operation in IAB is already specified. Simultaneously specifying both *no-TDM* and different DC scenarios based upon those no-TDM cases will be significantly more complex and inefficient and may result in an incomplete specification considering the current TU allocation for IAB. |
| Nokia | Yes | Agree with HW comment. It is too early to preclude any discussion on this. |
| ZTE, Sanechips | The answer may depend on what DC scenarios are taken into account. | It seems we need to know what DC scenarios are taken into account (i.e., will be brought into Rel-17 scope) when answering this question.  If the “DC scenario” only refers to “intra-carrier DC” and “inter-carrier DC”, the chance can be such that there is no “different DC scenario” if “intra-carrier DC” fails to enter the scope.  If the DC scenarios cover more, it is better to explicitly agree the list first. |

Additionally it was proposed that the level of required coordination and timing alignment between the parent nodes needs to be further considered since these factors impact resource allocation in DC scenarios. As pointed out by Samsung in R1-12006165, intra-donor DC scenarios are the baseline from Rel-16 and inter-donor scenarios need to be first discussed in RAN3.

**FL Proposal 3.2.2: Further consider the required coordination (at least under the same donor CU) and timing alignment between parent nodes to support resource allocation for different DC scenarios.**

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 3.2.2?** | **Comments** |
| Huawei | Some clarification are needed | We do not see the urgency to agree on this proposal before clarifying whether intra-band DC should be supported. In addition, the timing alignment aspects are unclear. |
| Ericsson | Yes |  |
| Nokia | Yes | This may not be necessary for all multiplexing scenarios. |
| ZTE, Sanechips | At least depends on the decision for intra-carrier DC | In addition, we think it is necessary to decide which of following path should be taken in RAN1 to handle multi-parent DC.   * Handle the DC with respect to nature of DC (i.e., loose coordination and timing alignment) * Handle the DC by adding “coordination/alignment” that could be somehow “required” by IAB performance improvement. Such coordination/alignment may not be adopted/defined for DC of UE. |
|  |  |  |

## Solutions/enhancements for Dual Connectivity Scenarios (Low priority):

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

**Summary of input contributions:**

|  |  |
| --- | --- |
| **Huawei (R1-2005260)** | ***Observation 3:*** *Inter-band DC and multi-TRP transmission in Rel-15/16 can be reused by IAB-MT without additional specification impact.* |
| **Vivo (R1-2005399)** |  |
| **Nokia, Nokia Shanghai Bell (R1-2005535)** | **Proposal 3.1: For IAB-MT DC scenario, RAN1 shall investigate the rules of using resources when there are two MT configurations received with the configured MCG and SCG.**  **Proposal 3.2. An IAB-node should be able to determine how to schedule the child link connections being part of the child node DC connections, either MCGs or SCGs.** |
| **Lenovo, Motorola Mobility (R1-2005927)** | **Proposal 3:** Define signaling for IAB nodes in the DC mode to inform parent IAB nodes of the status of the availability of soft resources. |
| **AT&T (R1-2005951)** | **Proposal 1: Per-link IAB-DU resource configurations and signaling between multiple IAB-nodes/donors should be considered in Rel-17.** |
| **Samsung (R1-2006165)** | ***Proposal 3: Discuss whether or not separate signaling between IAB MT and different parent IABs are necessary in Rel-17.***  ***Proposal 4: Discuss how to address scheduling collision issues for child IAB between MCG and SCG.*** |

**FL Proposal 3.3.1: Existing Inter-frequency DC and multi-TRP transmission features can be reused at the IAB-MT to support concurrent BH links to two parents without additional specification effort.**

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 3.3.1?** | **Comments** |
| AT&T | Yes | However given an IAB-MT may have advantages over an UE in terms of larger panels, higher Tx power, etc. optimizations should be considered to improve system performance of these features. |
| Huawei | Yes | None |
| Ericsson | No | In our opinion multi-TRP is not included in the dual-connectivity scenarios defined by RAN2/RAN3. Multi-TRP requires both parent nodes to communicate and coordinate extensively and speedily with each other and such parent-parent communication and coordination is far from guaranteed in IAB. |
| Nokia | Yes |  |
| ZTE, Sanechips | No | Share the view with Ericsson. |

**FL Proposal 3.3.2: The following categories of enhancements should be further considered to support DC scenarios (not an exhaustive list):**

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

**Discussion:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 3.3.2?** | **Comments** |
| AT&T | Yes | Discussion of enhancements for multiplexing cases should jointly consider operation of one or two parent links |
| Huawei | Partially | First of all, this proposal is a further step after the support of intra-band DC scenario are clarified.  Secondly, on the 1st bullet, we think the inter-parent DU coordination can be merged into the 2nd bullet, and the inter-DU signaling is not possible based on current system architecture.  For the 3rd bullet, we think it is just one possible solution for the 2nd bullet.  In general, there is no urgency to agree on this proposal. But once the clarification regarding FL Survey 3.1.1 becomes clear, we suggest further considering the following revised proposal  **FL Proposal 3.3.2: The following categories of enhancements should be further considered to support DC scenarios (not an exhaustive list):**   * **~~Inter-parent DU resource coordination mechanisms and signaling~~** * **Resource allocation/scheduling conflict resolution rules at the parent or child node** * **~~Per-link IAB-DU resource configurations at the parent node~~** |
| Ericsson |  | We would appreciate a clarification about the role of per-link DU configuration (related to a multi-child scenario) in DC considerations, if the configuration is beyond configuring NA resources.  Furthermore, unless we agree to the intra-carrier DC, we are not convinced of the usefulness of bullets 1 and 2. |
| Nokia | Yes | Resource coordination is important in DC scenarios and we agree with the FL. We think that this should be the main focus of DC related resource multiplexing. RAN1 shall also find the DC cases that are relevant, and the discussions may vary depending on different DC situations. |
| ZTE, Sanechips | Depending on decision on intra-carrier DC | If intra-carrier DC is not supported in Rel-17, there is no need to discuss the first two bullets. |

# Summary

TBD