3GPP TSG-RAN WG2 Meeting #112-e R2-20xxxxx

E-meeting, …, 2020

Agenda Item: …

Source: Qualcomm Incorporated

**Title:** [Post111-e][903][eIAB] Topology adaptation enhancements RAN2 scope

Document for: Discussion

# Introduction

The discussion handles:

* [Post111-e][903][eIAB] Topology adaptation enhancements RAN2 scope (Qualcomm)

 Scope: Aim to clarify the scope. Determine which technical issues to address in RAN2 as a part of this WI objective. Identify and clarify driving scenario(s). Determine work split R2 R3 when / if applicable.

 Intended Outcome: Report

 Deadline: long

The email discussion has two parts.

* Part 1: Identification of enhancement candidates to be handled by RAN2 under the topology adaptation topic. **Deadline: Sept 30, 23:59 PT**.
* Part 2: Clarification, consolidation, down-scoping of candidate features.

As a reminder, the WID includes the following objectives on topology adaptation enhancements [1]:

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| --- |
| *Topology adaptation enhancements [RAN3-led, RAN2]:** *Specification of procedures for inter-donor IAB-node migration to enhance robustness and load-balancing, including enhancements to reduce signalling load.*
* *Specification of enhancements to reduce service interruption due to IAB-node migration and BH RLF recovery.*
* *Specification of enhancements to topological redundancy, including support of CP/UP separation.*
 |

The Annex further includes agreements from last RAN3 meeting (R3#109e) on the topology adaptation enhancements topic.

# Phase I: Identification of enhancement candidates

## Purpose/benefit of enhancement

Before discussing specific features for topology adaptation enhancements, we need to converge on what these features are supposed to accomplish, e.g., if they aim to support an additional use case, improve on a specific performance indicator, etc.

In the further discussion (below), we will evaluate if and how well each feature proposed can meet/achieve at least one of these purposes/benefits.

**Q0: Please provide your company’s views on the main purposes/benefits to be expected from topology adaptation enhancements**

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| **Company** | **Comment** |
| Kyocera | We think Rel-17 should provide more robust IAB operations under uncertain BH link quality, such as the frequent shadowing in mmWave and/or the mobile IAB.  |
| LG | Main purposes/benefits of topology adaptation enhancements should be:* Reducing recovery time and Minimizing service interruption time incurred by BH RLF.
* Increasing reliability thorough path diversity
 |
| Huawei | This is for topology update due to some IAB node located in the cell edges of two donors. BTW, the purposes is clear from the WID itself, including service interruption reduction, robustness, topology redundancy, etc. So, any enhancement aligned with the WID scope can be discussed below in this email for R17. |
| samsung  | In our understanding, this feature has the following purposes and benefits: * Load balance among different IAB nodes/IAB donor DUs/IAB donor CUs
* Improve the robustness of backhaul links served by the IAB node
* Reduce the data transmission interruption due to channel status degradation or backhaul link failure
* Improve the reliability of control plane signalling
 |
| Ericsson | Related to topology adaptation enhancements, we believe that the main purposes for Rel.17 should be load balancing, especially when inter-CU migration is in focus. Intra-CU load balancing is already possible in Rel.16, but how to realize that in inter-CU framework should be studied by RAN2/RAN3.Increased robustness can also be considered, even though RLF should be a rare even in a static IAB network, especially in inter-CU scenarios.RAN2 has a lot of discussion to address RLF enhancements for inter-CU case. However, these aspects need to be considered:* IAB deployments will only happen in specific scenarios
* It will be rare that in these specific scenarios, some cells are under the control of two distinct CUs
* CUs are not dimensioned to carry own traffic plus neighbors cells, especially for IABs which may aggregate lots of traffic.
* RLFs can be mainly avoided by proper planning
* Considering all these aspects, enhancements for RLF in inter-CU scenarios will be unlikely to be implement as the scenario as such (RLF + inter-CU) will be an extremely rare case.

Load balancing may make more sense and it would be reasonable to study load balancing solution which may also address the RLF case. But aiming at RLF-only solutions should be avoided. |
| Intel | The main purposes to improve topology adaptation can be included into following aspects: 1) improve topology adaptation efficiency considering channel quality, RSRP, etc 2) improve robustness during topology adaptation, such as packet loss, etc 3) latency reduction in topology adaptation and recovery procedures |
| vivo | The main purpose is to support one IAB node and its downstream nodes fully/partially migrate from a CU network to another CU network. At the meantime, we shall: 1. Reduce service interruption in case of inter-CU migration;
2. Reduce the signalling storm for migration.
 |
| ZTE | Topology adaptation enhancements are expected to enhance robustness in R17 IAB. For example, the radio link quality in the backhaul link deteriorate due to blockage, then IAB node could perform migration procedure to avoid BH link radio failure and to ensure service continuity. With regard to load balance, it could be achieved by some other methods, e.g. topology redundancy via dual connectivity, multi-path routing, UE handover, etc.  |

## Candidates for enhancements

This subsection aims to identify candidates for topology adaptation enhancements. We start with candidates that were discussed during Rel-16, in contributions to R2#111e, and/or in the last RAN3 meeting (R3#109). At the end of this subsection, further candidate enhancements can be proposed.

Each candidate should be evaluated with respect to:

* **Purpose/benefit**. It should be assessed which of the above purposes/benefits (section 2.1) are addressed by the candidate and how effective the enhancement is in that respect.
* **Technical solution**. The solution may be obvious for some enhancements, but it may need more discussion for others. At this stage, the description should establish a rough baseline. Discussion on details, optimization, etc can follow later.
* **Potential shortcomings**.Some features may have great benefits but also significant shortcomings. It is important to understand this trade-off.
* **Specification effort**. This will be a coarse estimate. It should also be identified, which WGs have to be involved.

The discussion rapporteur has allowed himself to provide guidance, i.e., emphasize where clarification is needed for an enhancement, or elaborate on where and how RAN3 has already made progress.

### 2.2.1 CHO

Proposed by R2-2006626, R2-2006967, R2-2007167, R2-2007501, R2-2007863, R2-2008025, R2-2008026, comment by RAN3 chairman

RAN3 chairman added to notes:

**CHO should be supported for IAB-MT.**

Chair: unless excluded, normally current functionality is applicable

**Q1: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We assume CHO can be used for IAB as it is, from Rel-16. In case of BH RLF in Rel-16, however, cell selection for RRC Reestablishment is triggered, but CHO is only executed when the IAB-MT selects a cell that is in the CHO configuration. In addition, CHO is never triggered if the BH RLF happens at the parent node, since the radio condition of BH link at the concerned IAB-node is still good. We think more deterministic behaviour for full utilization of CHO is desirable for Rel-17 eIAB and assume it could be solved by a new triggering condition for CHO, e.g., upon reception of BH RLF Indication.  |
| LG | CHO is a useful way to reduce recovery time upon occurrence of BH problems. However, it should be noted that it is completely unknown when the conditional mobility actually occur and hence preparation should be done for many UEs. |
| Huawei | Agree to support CHO for R17 IAB-MT;**Purpose/benefit**: migration robustness**Technical solution**: reuse R16 CHO for UE**Potential shortcomings**: some minor standard efforts**Specification effort**: To discuss the behaviour of child MT/UE upon CHO for parent node. |
| Samsung  | * Purpose/benefit: This is straightforward to be supported. CHO is responsible to reliability enhancement. NR frequency could be vulnerable and CHO can recover this. Since single CU can handle the resource management for different IAB node as the target cell, there is less complexity of CHO in IAB case than normal UE’s CHO where inter node signalling is necessary.
* Technical solution: IAB MT can be configured for the condition to excute CHO to predefined IAB parent node, and upon condition met IAB MT will execute CHO without signalling.
* Potential shortcomings: We don’t see any potential short coming since already this is supported by normal UE.

Specification effort: Almost same solution as the normal UE can be applied, so not difficult to specify this further.  |
| Ericsson | CHO can be considered already supported for Rel.16. However, if the intention is to enhance CHO functionalities for the sake of IAB networks, e.g. to make it more robust in case of RLF, we are a skeptical.CHO has been designed in Rel.16 to make mobility more robust. In CHO, the UE does not need to wait for an HO command to trigger the HO. Rather, the UE itself can trigger an HO when certain conditions configured by the network, i.e. A3/A5 events, are fulfilled. One critical aspect of CHO is that the source cell should prepare one or more target cells well in advance before the actual HO is triggered at the UE side.Since IAB nodes are not moving, it is certainly not reasonable for a source CU to prepare a target DU/CU for an undefined amount of time, just for the sake of an RLF that in this type of network will likely occur very rarely. |
| Intel | We support CHO functionality should be considered for IAB-MT to reduce service interruption during both intra-CU and inter-CU migration. However, some modification may be considered in IAB scenario, especially IAB node with multiple parent nodes. |
| vivo | Conditional handover has the following benefits/purposes:* Guide an IAB node to find a proper new parent IAB node in case of RLF occurrence;
* Reduce the service interruption in case of RLF by quickly moving to the preconfigured target parent IAB node using CHO command;
* Avoid signalling storm for IAB network to migrate from a CU to another CU compared to traditional handover procedure;

For CHO handover of an IAB node from a CU to another CU, we shall consider that the IAB node and its downstream nodes migrates together from the source CU network to the target CU network. The detail procedure is FFS. |
| ZTE | We generally think CHO can be supported in R17 eIAB to reduce service interruption. The migrating IAB-MT can perform the CHO procedure as R16 UE. It is suggested to reuse legacy CHO procedure without additional specification enhancement. |

### 2.2.2 DAPS

Proposed by R2-2006626, R2-2007501, R2-2007863

Please include aspects such as:

* If DAPS would be used for reduced interruption time of MT handover or to create a prolonged state of topological redundancy between source and parent nodes.
* If and how intra-frequency handover would be supported for FR1 and/or FR2. How resource allocation would be managed during handover between multi-vendor nodes.

**Q2: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We don’t have strong view, but be wondering what DAPS means for IAB, e.g., since there is no PDCP layer in intermediate IAB-nodes on multi-hop relaying path.  |
| LG | Not prefer to include DAPS for IAB.DAPS has been specified for 0ms user plane data interruption, and the PDCP has an important role as an anchor point in DAPS. However, there is a BAP entity and no PDCP entity for forwarded user plane data in the intermediate IAB nodes. If it is determined to support DAPS in IAB node, the current DAPS mechanism would not be a baseline and huge RAN2 and RAN3 (maybe RAN1 as well) work are expected.  |
| Huawei | Agree to support DAPS for R17 IAB-MT;**Purpose/benefit**: supporting the DAPS of migrating IAB-MT can reduce the service interruption of this IAB node. Also it provides the simultaneous connections with both source and target donor. At least, we can support the inter-frequency HO with DAPS. We can further discuss the intra-frequency case after R1 finalize the support of intra-frequency DC for IAB. **Technical solution**: reuse R16 DAPS for UE**Potential shortcomings**: N/A**Specification effort**: Minor, if we only support the DAPS of migrating IAB-MT. |
| Samsung  | DAPS is a misleading word here. The main purpose of this solution is to allow IAB-MT to keep the connection with the source path while performing the migration. Thus, the data transmission can be kept with source path until the source path is ready. We propose to call this solution as “DAPS”-like solution. * **Purpose/benefit**: it can reduce the interruption time since the IAB-MT can use the source path for data transmission until the target path is ready.
* **Technical solution**: during the IAB node migration procedure, the IAB-MT can keep the connection with its source parent node. Thus, the data transmission can be continuously performed before the target path is ready.
* **Shortcomings:**

We didn’t see very explicit shortcomings. One concern from our side is that how to keep the UL transmission at the source path. In Rel-16 DAPS, the UL transmission at the source is stopped after success RACH. However, in IAB, we may need keep UL transmission at the source path even after success RACH. As a network node, we think keeping such capability may not be a problem. Anyway, we can discuss the details about this after confirming this “DAPS”-like solution in Rel-17.* **Specification efforts:**

 In our understanding, the normal IAB migration procedure (without considering any enhancements on, e.g., interruption reduction, signalling overhead reduction, etc) will be the baseline when we determine the specification effort. Thus, on top of the normal IAB migration procedure, such “DAPS”-like solution would not cause too much specification effort. The additional enhancements may include, e.g., configure to IAB node on keeping the BAP related configuration at the source path, release the source path after target path is ready, etc. For intra-frequency handover, we need consider this issue. However, in Rel-16, DAPS also face the same problem. Thus, we need first look at the solutions used in Rel-16 DAPS, and then decide if further enhancements are needed or not.  |
| Ericsson | We are skeptical about the usage of DAPS in IAB, at least if the Rel.16-type of dual active protocol stack is considered here.As mentioned by LG and Kyocera, DAPS works at PDCP level, so how to make it work at BAP level might require significant amount of work. Additionally, DAPS is mainly intended to enforce the DL. In fact, while the dual DL from source and target cell can be kept until the target releases the source cell configuration, the UE can only perform UL UP communications with the target cell after HO successful completion.Given the above reasons, we foresee that non-trivial standardization work might be needed to make DAPS suitable for IAB. |
| Intel | We think it needs FFS on how DAPS can be used for IAB-MT handover |
| vivo | DAPS has the following disadvantages:* Even if DAPS is to be used for an IAB node, it means DAPS has to be used for each of its downstream nodes as well to ensure data transmission robustness. However, a downstream node may only have single radio connection, which makes DAPS not configurable for this downstream node.
* DAPS is only applicable for DRB while DRB for IAB-MT is optional feature at this time;

If DAPS is to be used, enhancements are needed so that DAPS can be supported for each migration node in the migration network, which seems very complex, if not impossible. |
| ZTE | We generally think DAPS can be supported in R17 eIAB. With DAPS, IAB-MT may perform DL reception from source parent DU and the target parent DU simultaneously after receiving the HO command, so that service interruption time could be reduced during handover. In addition, we may start with the inter-frequency DAPS handover in Rel-17. The intra-frequency support may be further discussed if it’s decided to include this scenario in Rel-17 IAB.  |

### 2.2.3 CP redundancy via separate NR access link

Agreed by RAN3.

This enhancement defines the analogue of F1-C routing via LTE/X2 for standalone, i.e., for IAB-nodes that use NR-DC instead of EN-DC.

RAN3 agreed on the following functionality:

**Consider Scenario 1 and 2 for CP/UP separation:**

**Scenario 1: F1-C via M-NG-RAN node (non-donor node) + F1-U via S-NG-RAN node (donor node)**

**Scenario 2: F1-U via M-NG-RAN node (donor node) + F1-C via S-NG-RAN node (non-donor node)**

Please capture the RAN2-related aspects for this enhancement.

**Q3: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We think the CP redundancy in NR-DC is beneficial to be introduced as the same gain considered in EN-DC IAB. We assume it would be specified with the same solution with what Rel-16 did for EN-DC IAB, i.e., F1 container in RRC message.  |
| LG | Not prefer to discuss this issue in this email discussion and want to wait more RAN3 progress.It’s too early to figure out clearly what the RAN3 identified issue and we also think it is not urgent from RAN2 point of view and the RAN2 discussion/conclusion may be different depending on RAN3 decision/progress. Thus, we would like to discuss other RAN2 originated issues first, which are based on the contributions submitted in the last RAN2 meeting and it would be better to wait RAN3 progress on it and then RAN2 can start to discuss this issue based on more concrete RAN3 conclusion/progress. |
| Huawei | Not support the scenario 1 and 2**Purpose/benefit**: We supported the EN-DC case in R16. If we want to support the F1-C on FR1 but F1-U on FR2, we can also reuse the NR-DC in R16, with F1-C on one FR1 BH path while F1-U on another FR2 BH path. We need to clarify if any purpose/benefit is not supported in R16.For the new deployment case, where F1-C is on the non-backhaul NR link of FR1, we are not sure if this is explicitly under WID scope. “support of CP/UP separation” is in the scope, which is already supported by R16. But “CP redundancy via separate NR access link” may require the update of WID.**Technical solution**: reuse R16 F1-C over LTE (only if the scenario is agreed by R2)**Potential shortcomings**: less benefits but require new discussion.**Specification effort**: This may also open more discussion on how IAB-MT integrates in the NR-DC with non-backhaul MN. |
| Samsung  | * Purpose/benefit: This can ensure the reliability of control signalling. for scenario 1, it has the same benefit as in ENDC case, i.e., has more reliability on controlling F1-C. for scenario 2, it is also effective to have more reliability of control signalling if different FR is used with ENDC.
* Technical solution: as described by rapporteur
* Potential shortcoming:
* Specification effort: we can take ENDC case as the baseline scheme. The specification impact would not be too much. The details can be further discussed later.
 |
| Ericsson | We don’t have a strong opinion on this topic but RAN2 should first wait for RAN3 progress. |
| Intel | We agree with RAN3’s agreement. |
| vivo | Of the two enhancement candidates we see Scenario 1 is meaningful. It helps improve the signalling robustness, e.g. when MN is macro gNB and micro gNB can provide high data rate over SN link.Good use cases need to be found for Scenario 2.Maybe we should wait for further RAN3 progress |
| ZTE | These two scenarios are similar to the F1-C over LTE scenario discussed in R16 IAB. In R16 IAB, RAN2 discussed how to transfer F1-C traffic over LTE Uu interface. It was agreed to encapsulate F1-C traffic in LTE RRC. SRB2 is used for transporting the F1-C traffic Similarly, In R17 IAB, RAN2 may consider how to transmit the F1-C traffic over NR Uu interface, the design of protocol stack. The solution of R16 F1-C over LTE can be reused as much as possible. |

### 2.2.4 Redundancy via inter-donor NR-DC

Agreed by RAN3.

RAN3 agreed on the following functionality:

**Analyze Scenario 1 and Scenario 2 for inter-Donor Topology Redundancy, with the principle that an IAB-DU only have F1 interface with one Donor-CU:**

**Scenario 1: the IAB is multi-connected with 2 Donors.**

**Scenario 2: the IAB’s parent/ancestor node is multi-connected with 2 Donors.**

Please capture the RAN2-related aspects for this enhancement.

**Q4: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We’re wondering what the “multi-connected with 2 Donors” means from RAN2’s perspective, i.e., whether it’s a normal DC (single RRC connection) or an IAB-MT has dual RRC connections.  |
| LG | Not prefer to discuss this issue in this email discussion and want to wait more RAN3 progress.It’s too early to figure out clearly what the RAN3 identified issue and we also think it is not urgent from RAN2 point of view and the RAN2 discussion/conclusion may be different depending on RAN3 decision/progress. Thus, we would like to discuss other RAN2 originated issues first, which are based on the contributions submitted in the last RAN2 meeting and it would be better to wait RAN3 progress on it and then RAN2 can start to discuss this issue based on more concrete RAN3 conclusion/progress.  |
| Huawei | We prefer to first identify the R2 impacts before we agree on any of those scenarios. We also prefer to discuss this later after we have some progress on the basic inter-CU migration procedure. Note that this was not agreed by R3 yet (it is only to **analyse**). **Purpose/benefit**: 1) For the case of inter-CU migration, the service interruption reduction can be achieved. We need to finalize how the inter-CU migration procedure works before we agree on the support of the above two scenarios. It seems we already have sufficient interruption reduction with the agreed R3 cases “IAB-MT is simultaneously connected to two IAB-donors + IAB-DU is simultaneously connected to 2 donor-CUs”;2) For the case of F1-U redundancy when there is no migration, this could bring the topology redundancy for the IAB node in the middle of two donors. Not sure if this is the common deployment.**Technical solution**: To be discussed**Potential shortcomings**: not clear on the benefits but require more standard impact and efforts.**Specification effort**: How the BAP path/BH RLC under the target donor and the corresponding IAB nodes are controlled/configured by source donor requires significant discussion and spec impacts. |
| Samsung  | - Purpose/benefit: there must be a physical boundary of a single donor CU due to the propagation delay and physical maintenance on connection between CU and IAB nodes. Therefore, in the border area of two different donor CUs, keep connection with two different donor CUs at IAB node seems reasonable for link vulnerability.- technical solution: described by rapporteur- potential shortcoming: any specific shortcoming found- specification effort: in the initial estimate, not much since current RRC signalling on MRDC can be used for this i.e., separation of MN/SN is assumed. The main impact may be at RAN3.  |
| Ericsson | The RAN3 agreement is too vague and can be interpreted in different ways. So, this makes it difficult for us to assess the RAN2-related aspects of this agreement.  |
| Intel | We agree with RAN3’s agreement and RAN2 should consider redundancy enhancement of local routing and configuration maintenance of descendent IAB nodes during inter-donor NR-DC migration after RAN3 further progress. |
| vivo | This seems the scope of RAN3. For scenario 1, the IAB node itself can perform local-rerouting according to preconfigured conditions.For scenario 2, it is preferred that it can be achieved by means of local-rerouting of the parent/ancestor IAB nodes, i.e. the IAB node itself is transparent to path selection/rerouting of its parent/ancestor IAB nodes.  |
| ZTE | RAN3 firstly discussed these two scenarios during last meeting. No more details were given. RAN2 is suggested to wait for more RAN3 progress before discussing the RAN2 impacts.  |

### 2.2.5 Redundancy using routing via descendant nodes

Proposed by R2-2006967, R2-2007023, RAN3 agreement

RAN3 agreed that:

**Routing Enhancement via descendant node can be discussed later or after RAN2 decision.**

This enhancement aims to leverage route redundancy via a dual-connected descendant node, e.g., in case of upstream RLF.

Please include the following aspects:

* Applicability to CP vs. UP
* Conditions to use descendant-node path, e.g., only at upstream RLF or also for other reasons

**Q5: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | In Rel-16, the IAB-node, experiencing upstream BH RLF, first tries RRC Reestablishment to the descendant node (if selected), and then it transmits UP data to the new parent. If Rel-17 still follows this principle, we think it ends up the enhancements of cell selection. The descendant node can be the candidate of cell selection unless its RRC connection (i.e. CP path) goes through the concerned IAB-node (i.e., the one experiencing BH RLF). We need further clarification of the intended solution, if the intended solution aims to UP data transmissions/re-routing to the descendant node without RRC connection to the IAB-donor (i.e., it’s broken by upstream BH RLF).  |
| LG | This requires complex operation unnecessarily. For example, the IAB node should know the descendant IAB node has a route to the intended destination IAB node in advance because if there is no path to the intended IAB node in the descendant node, the IAB node cannot use this descendant IAB node as redundancy. Furthermore, in Rel-17, two different IAB donors may be used to transmit CP/UP data. In this condition, if the descendant IAB node has a path to only one IAB donor, the IAB node should select packets which can be forwarded to the descendant IAB node. Another point is that when the routing configuration or channel condition is changed in the descendant IAB node, this information should be indicated to the parent IAB node to avoid unnecessary data forwarding from the parent IAB node. Given this aspects, we doubt whether there is much gain to overcome this complex and how frequently use this redundancy route. |
| Huawei | Agree to support this for both CP and UP. The condition to use this can be same as the R17 condition for local re-routing.**Purpose/benefit**: This is for service interruption reduction in case at least RLF, and for robustness, topology redundancy. This is to support the missing upstream topology redundancy in R16, where parent IAB node has no DC but child IAB node has DC.**Technical solution**: allow IAB node forwards the upstream data to its child node in case at least for RLF. No need to change the topology between parent and child node. The backup BAP path via descendant node is configured by CU as ususal.**Potential shortcomings**: N/A.**Specification effort**: Minor or barely not spec impact. Some clarification in 38340 may be needed. |
| Samsung  | First of all, this seems to be a sub category of mesh network that only UL broken triggers the detour. We first to check this topology can be agreed in RAN2.* Purpose/benefit: route redundancy can be enhanced, and reduce the interruption time.
* Technical solution: if UL RLF is detected, IAB finds alternative path using its child node
* Potential shortcoming: every IAB node has to maintain this additional set of route information per UL path. Once topology has been changed, all the related route information also should be signalled to reflect the latest one. Also, packet those been rerouted can have uncontrolled delay. To resolve this, there should be a longevity metric for packet handling in each IAB node.

The method may cause a lot of impacts. For example, a topology is donor DU 🡪 IAB node 1 🡪 IAB node 3, and donor DU 🡪 IAB node 2 🡪 IAB node 3. If the RLF occurs between donor DU and IAB node 1, the re-routing path becomes IAB node 1 🡪 IAB node 3 🡪 IAB node 2 🡪 donor DU. In this re-routing path, IAB node 1 has to re-send the packets received from IAB node 3 back to IAB node 3, and then IAB node 3 resends the packets to IAB node 2. This causes the data transmission re-direction, i.e., IAB node 1 redirect its UL data to DL, and IAB node 3 redirects its DL data to UL. Is this redirection technically feasible currently? To achieve redirection, the BAP routing ID should be changed by IAB node, is this aligned with Rel-16 design?In addition, this method may be only applicable for the case that such re-routing path is under the same donor DU, which restricts its benefit. Considering the limited time unit, we think it is better to focus on the fundamental and important issues at this stage, and de-prioritize this scheme.Specification effort: BAP spec needs to enhance this aspect, e.g., the BAP header change may be needed. Compared to the actual signalling between CU and each IAB node, the spec might not have much impact since CU is anyhow in charge of configuration of this info. However, the impact of data transmission redirection should be evaluated.  |
| Ericsson | We agree with LG analysis. In our view, this enhancement will require significant specification effort without any real benefits. Thus, RAN2 should de-prioritize this topic. |
| Intel | It is not clear to us how to reuse descendant nodes in this case, 1) whether IAB-MT at parent node access to IAB-DU at child node (the previous child node is now parent node), or 2) previous upstream traffic is sent as downstream data to child node indicating it’s upstream data from parent node, and child node forwards the data via another existing path through another parent node. Comparing above two options, we prefer routing via descendant nodes can be further discussed within scope of option 2) for CP and UP. |
| vivo | It may not be the case that each IAB node in the IAB network knows the alternative ways to any donor IAB node in the network. There could be ping-pong transmissions of packets if wrong next hop is selected in complex topology cases. Furthermore, in case of RLF, the stalled transmission during long RLF detection period must probably already trigger TCP retransmission, which makes rerouting useless. Given the time budget of the work item, let’s still leave it for implementation in Rel-17.  |
| ZTE | The re-routing via descendant node may exploit new available path during RLF and thus improve service continuity. However, it introduce more hops and thus longer delay for backhaul traffic forwarding. In addition, the same data packet might be re-routed to and from a intermediate IAB node multiple times. New BAP header might be designed to avoid this problem. Nevertheless, we think the benefits are trivial and it is better to de-prioritize this re-routing scenario. |

### 2.2.6 Redundancy via collocation of multiple MTs

Proposed by R2-2006967, RAN3 agreement

RAN3 agreed that:

**Multi-MT Support is FFS in RAN3 pending RAN2**

This enhancement was already discussed during Rel-15 SI. Please provide a brief outline on the technical solution with an emphasis on what could be accomplished via implementation and where specification would be necessary.

**Q6: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We’re wondering what impacts is foreseen from RAN2’s perspective, since TR38.874 states in section 9.7.8 that “*Multi-connectivity of IAB-node (Case 2 above) can be supported by* […] *using several independent MT functions in the IAB-node, where* ***each MT function makes an independent connection*** *to the network (using normal MT setup).*” |
| LG | Not prefer to support multi-MT.We think that this needs complex inter-operation between one IAB-DU and multiple IAB-MT and between multiple IAB-MTs. For example, given that IAB-MT is considered as sort of UE, if multiple IAB-MTs are supported, it should be clarified whether each IAB-MT has RRC connection or one RRC connection manages all multi-MTs in one IAB node. BAP specification may be impacted to handle the case of two IAB-MTs and one BAP SDU is given to be forwarded since each IAB-MT has one BAP entity which handles routing ID determination and selection of next hop IAB node. In addition, inter-operability between IAB nodes would be also complex. |
| Huawei | Not to support this.**Purpose/benefit**: The benefit seems for UL redundancy with more than 2 links. With single MT, we can support the 2 link redundancy. With two MTs, we can support the 4 link redundancy. However, the performance gain is small when we compare 4 links to 2 links. Since we do not support the BAP layer duplication, the rest 3 backup links can only be used if the primary link is under RLF. Base on R16 design, only 1 backup link is sufficient, because there is no benefit to select among 3 or more than 3 backlinks if anyway we only support the BAP data via single path at a give time.Anyway, multiple MT is not under the WID scope.**Technical solution**: In R16, we agree to use the multiple MT redundancy by implementation, by combining the two pair of DU&MT or two IAB nodes in one box. We see no big difference in R17.**Potential shortcomings**: whether this works requires R1 analyses.**Specification effort**: Significant R1 impact. How the BAP at MT side works is to be discussed (e.g. shared or dedicated BAP for the multiple MTs). |
| Samsung  | **Purpose/benefit**: the intention is to extend the number of connectivity of an IAB node. So, the number of routing paths of an IAB node can be increased. However, we are wondering how much benefit can be brought by such method: 1) the number of available routing paths of an IAB node can be increased with the increase of the number hops. Specifically, the parent node of an IAB node can have dual connectivity, and its grandparent can also have dual connectivity; 2) if multi-MT is introduced, the coverage of a logical IAB-MT would be reduced since the maximum transmission power is limited. Thus, the increase of routing path number is reached at the cost of reducing the coverage of an IAB node. **Technical solution:** as discussed in both Rel-15 and Rel-16**Potential shortcoming:*** Multi-MT may cause the coverage reduction of an IAB node since multiple MTs should share the same transmission power limitation
* The close coordination among parent nodes serving different MTs at the same IAB node is needed. For example, those MTs cannot be scheduled to the same time-frequency resource; those MTs cannot be allocated the same transmission direction (e.g., DL, UL) at any time. To solve this problem, the FDM or TDM can be applied. However, this will reduce the capacity of one IAB-MT.
* The specification impact is not neglected. It will introduce impacts among WGs, including RAN1/2/3.

**Specification impact:*** RAN1: TDD configuration coordination, RS signalling coordination, power control, etc.
* RAN2: initial access (when one IAB-MT, e.g., IAB-MT1, already accesses the network, how to perform the initial access of another collocated logical IAB-MT, e.g., IAB-MT2, without impact the IAB-MT1 ?), scheduling coordination, BAP configuration enhancement, etc
* RAN3: in this scheme, multiple MTs are shared by the same IAB-DU. Thus, how to configure the routing and bearer mapping needs further analysis.

In addition, multi-MT seems to be a comprised method to support the multi-connectivity due to no support at the normal UE case. We are wondering if we need spend effort on such compromised method. In our opinion, the better way is to start the study on multi-connectivity for normal UE first, and then check if any further enhancement is needed for IAB case. Based on above analysis, we prefer to de-prioritize such multi-MT solution.  |
| Ericsson | It would be good to define multi-MT. In our view, multi-MT would be equivalent to have one MT with multiple protocol stacks, similar to DAPS but just having the protocols which an intermediate IAB node has. It can be called multi-MT, double IAB protocols, or any other suitable name. But the concept is simple. One protocol stack is connected to one CU and a second protocol stack is connected to another CU.In our understanding, multi-MT provides a simple solution for supporting multiple connections to the IAB node(s) without the limitations associated with the current DC-based solution, or with the current DAPS solution (as mentioned in our reply to Q2).When it comes to specification effort, we believe that is feasible in the WI time frame. The only additional functionality required is to ensure that the different MT connections are set-up via different radio paths, which can be ensured by implementation. From an RRC signalling perspective, the multiple MTs will look like independent MTs and can receive separate configurations and operate on independent links/channels.From RAN3 perspective, the multiple MTs of a given IAB node need to be associated/linked to the DU of the same IAB node. For the baseline case of a single-MT IAB node, RAN3 specification (TS 38.401) has defined the following approach for the IAB-donor-CU to discover collocation of IAB-MT and IAB-DU:“The IAB-donor-CU discovers collocation of IAB-MT and IAB-DU from the IAB-node’s BAP Address included in the F1 SETUP REQUEST message.”Thus, the same approach can be used to associate more than one MT to a given DU. |
| Intel | We are ok to study further on the complexity impact to the architecture, RAN1 and RAN4 should also study the impact |
| vivo | Multiple MT has impacts to RAN1, RAN2 and RAN3:* For RAN2, integration procedure via multiple MT has to be defined with the precondition that single F1 connection is assumed for single DU. There seems quite some standardization work;
* For RAN2/3, routing/flow control/RLF logic seems different, which also need some standardization effort;
* BTW, for RAN1, does multiple-MT means multiple logic or physical MTs? I think RAN2/RAN3 cannot estimate the standardization effort for this;

With existing basis, even with multiple MT, it seems difficult to set up a dual topology network with acceptable workload. It is a complex work and further studies are needed before entering WI phase. |
| ZTE | With multi-MT, IAB node could be connected with more than two parent node. However, we are doubt with the necessity and benefits. With dual-connectivity, IAB node could support topology redundancy and multi-path routing. We see no strong motivations for the multi-MT support.  |

### 2.2.7 Enhancements to RLF indication

Proposed by R2-2006626, R2-2006948, R2-2006967, R2-2007165, R2-2007773, R2-2007864, R2-2008025, R2-2008026

This enhancement was already addressed in a Rel-16 email discussion. To proceed where this discussion ended, rather than repeating it, please describe:

* Difference of Rel-17 RLF indication over Rel-16 RLF indication (e.g. condition of transmission, information carried, etc).
* How the expected purpose/benefit is achieved via such indication (e.g. what needs to happen upon reception of reception of this indication so that the benefit is achieved).
* Potential shortcomings, if applicable (e.g. uncontrolled behaviour, reestablishment at incorrect node, etc.).

**Q7: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We think… The additional indication is transmitted when the IAB node experiences BH RLF or be trying BH link recovery (a.k.a., Type 1 or Type 2), and/or when the IAB node successfully recovered BH link (a.k.a., Type 3). We assume Type 1 and Type 2 depicture the same condition. We prefer Type 1/2 Indication is sent via SIB1 since it allows not only IAB-MTs but also UEs to read/use it, while BAP control PDU is only readable by IAB-MTs. The child node(s), upon reception of Type 1/2 Indication, stop sending Scheduling Request, and/or it may decide to do the local re-routing (if introduced). As an implementation option, the child node(s) may prepare possibility of its BH recovery, e.g., pre-measurements. The child node(s) should resume the normal operation when the IAB node’s BH link is recovered. As an optimization, if Type 1/2 Indication is transmitted repeatedly (e.g., via SIB1), Type 3 Indication may not be needed, since the IAB node would stop sending Type 1/2 Indication when its BH link is recovered.  |
| LG | We suggest to introduce BH RLF indications that are triggered upon BH RLF and upon successful recovery of BH RLF. These additional indications would reduce service interruption significantly and benefit sustaining preferred/planned topology.  |
| Huawei | Agree to introduce two new RLF indication: type1/2: “BH recovering indication” and type3 as “BH recovered indication”;**Purpose/benefit**: The purpose is for the scope of reducing service interruption in case RLF. “BH link recovering indication” is to warn its child to prepare for the possible RRC re-establishment and allow child node’s local re-routing. “BH link recovered indication” is to notify the child node to go back to the normal operations.**Technical solution**: The child node behaviour upon reception of this indication needs more discussion. We don’t need to work on the detailed solution by this email discussion.**Potential shortcomings**: N/A.**Specification effort**: New BAP control PDUs. |
| Samsung  | * Purpose/ benefit: reduce the interruption time which can occur when Rel-16 RLF failure notification is only used.
* Technical solution: RLF indication is triggered when RLF is declared on the link to the parent node. If there is single parent node, and that node is on RLF, then any additional RRC control cannot be delievered to the IAB node. In this case, RLF detection indication can trigger the Cho type of command. Then IAB node can be switched without significant interruption.
* Potential shortcoming: not explicit shortcoming found

Specification effort: Already CHO is specified, so there not much thing to be considered further but some modification of execution condition including RLF detection indication. |
| Ericsson | In general, we support the enhancement of RLF notification messages, such as including “trying to recover” and “BH link recovered” messages, etc. This will enable the child node to prepare for possible performance degradation at the parent node or search for alternative parents or resume normal operations after parent node recovery.However, in our view, assuming that these RLF indications signaling are in place, it could be left to the implementation of the child/parent node how to behave. |
| Intel | Significant delays should be noted at each step through the network multiple hops, and performance cell search/measurement and read SI from candidate parents takes significant amount of time. Comparing with Rel-16 RLF indication, a more timing-advanced indication (type 2) is beneficial to reduce RLF recovery latency, that is, a downstream indication of RLF at an IAB node in addition to existing RLF failure indication in Rel-16. Type 2 indication can enable the descendant nodes to perform cell search measurements and prepare for a possible change of parent nodes. The type 4 indication in Rel-16 triggers the actual change of parent nodes. |
| vivo | * **Purpose/benefit**. Type 2 RLF indication allows the child node to take precautions against the potential performance degradation at the parent node, such as the searching for an alternative parent node. Type 3 RLF indication informs the child node that the parent has recovered from the RLF and the child node can resume the normal transmissions. Specifically, we’d like to specify the indications as well as the behaviours after the triggering of those indications, which were not discussed in Rel-17.
* **Technical solution**. Solutions would be quite straight-forward, two additional PDU types should be used for Type 2/3 indications.
* **Potential shortcomings**.There are 4 bits reserved for PDU types, which means that the control PDUs used for IAB can only be up to 16. Since 4 codes were already specified in the current spec, in this case, the trade-off is that the reserved PDUs will be left to 11.
* **Specification effort**. The foreseeable effort is negligible.
 |
| ZTE | It is suggested to include the type1/2 BH recovering indication and type3 BH recovered indication. If Type 1/2 indication is received, the child node may perform early measurements in order to prepare for possible BH RLF recovery. If Type 3 indication is received, the early preparation can be canceled. |

### 2.2.8 Avoiding RLF recovery at former descendant node

Proposed by R2-2006626, R2-2006948, R2-2006961, R2-2007773

This issue was already addressed during a Rel-16 email discussion. To proceed where this discussion ended, rather than repeating it, please describe the technical solutions on *how* RLF recovery at former descendant node is avoided.

**Q8: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We think the blacklist and/or the whitelist should be provided to the IAB nodes in order to prevent selecting unsuitable cells. We think the list(s) should be updated dynamically, considering frequent topology changes in Rel-17 eIAB nature. In this sense, we prefer RRC should manage the list(s), not OAM. We’re wondering if this enhancement may or may not be related to Q1 (i.e., CHO) or Q5 (i.e., Redundancy using routing via descendant nodes). So, RAN2 should consider the relationship of solutions and avoid the potential functional duplication.  |
| LG | We do not see the need of this; Cell selection during RLF recovery is already up to implementations, and hence the reasonable implementations would avoid this, i.e. no standardization work is necessary. WE observe that our arguments are further justified by the fact that that IAB topology should be well pre-planned, i.e. topological knowledge is well known a-priori to those IAB nodes.  |
| Huawei | No need of this.By implementation in R16, if one IAB node select its descendant node after RLF, there is no available path to the donor CU. Then, the RRC re-establishment procedure will fail anyway, due to no response from CU. As the consequence, IAB node will then select another cell.In addition, in the realistic IAB deployment, parent IAB-MT is usually not able to select child IAB-DU due to the beam forming. |
| Samsung  | * For LG/Huawei’s comment, in current 38.304 the following is said:

b) Cell selection by leveraging stored information:1. This procedure requires stored information of frequencies and optionally also information on cell parameters from previously received measurement control information elements or from previously detected cells.* “the stored information” is freq and cell parameters previously received from measurement control info. In detail, this would be measurement object and some cell list. So these are static information as stored in UE, and cannot reflect the the IAB specific topology and cannot filter any failed cell which is the dynamically changed.
* Purpose/benefit: reduce the interruption time on RRCreestablishment procedure for access UE as it is. This needs to be resolved since implementation information in legacy cell selection is not enough to handle this since only meas config information formerly used for RRM can be reused as the cell selection stored information, and this information cannot reflect the IAB node hierarchy.
* Technical solution: Method can be either CU’s signalling on cell information to be excluded or IAB node’s failure indicating “out of connection” in SIB1 so that this failed cell can be filtered by neighbour cells.
* Potential shortcoming: specification
* Specification effort: Idle spec or RRC needs to be modified to realize this.
 |
| Ericsson | As the rapporteur mentioned that this issue is already addressed in Rel-16, so it seems that the purpose of this discussion to enhance the solution set for avoiding RLF recovery at former descendant node. If so, then companies have to provide strong motivation for why RAN2 should discuss additional solutions for a problem that has already been solved. |
| Intel | As discussed in R2-2006948, upon receiving a recovery failure indication, an IAB node should not choose for reestablishment, parent nodes or ancestor nodes that have experienced RLF or have received a recovery failure indication. This can lead to significant delays and eventual failure.RAN2 should make modifications according to the following to ensure that an IAB node does not choose for reestablishment nodes that have failed:- A failed IAB node modifies system information to bar access to new IAB nodes or UEs; and- The recovery failure indication also includes information about ancestor nodes that have failed. The first modification above requires the IAB node to be able to locally modify system information (as opposed to the IAB node just transmitting the system information blocks provided by the CU). It is necessary to ensure that new IAB nodes do not attach to the failed node. The second modification enables quicker reestablishment since descendant IAB nodes do not need to acquire system information of the failed nodes.  |
| vivo | It seems good enough to leave it for implementation. We don’t see the serious impact when a former descending IAB node is selected as a candidate parent IAB node if this former descending IAB node has already setup radio connection to a new parent IAB node which can provide services after the descending IAB nodes receiving RLF recovery failure notification from its parent IAB node. Instead, it may result in suboptimal network topology if a former descending IAB node is the best candidate parent IAB node for an IAB node and the former descending IAB node is not allowed to be selected by this IAB node. |
| ZTE | Avoiding RLF recovery at former descendant nodes can be up to implementation. For example, if IAB node detects RLF and selects descendant node to perform RRC re-establishment, the re-establishment will definitely fail since no path available towards donor CU. In addition, suppose descendant IAB node receives the RLF indication, it may reject the access of IAB-MT or bar the cell.  |

### 2.2.9 Message bundling (e.g. “group mobility”)

Proposed by R2-2006961, R2-2007313, R2-2007863, RAN3 discussion

RAN3 had a discussion on this topic and the following issues were raised: While bundling of multiple, e.g., UE messages reduces the total number of messages, it does not necessarily reduce the processing load. Further, bundling is restricted by the upper bound of the message size.

Please include in your comments what type of messages you believe the bundling could apply to, and please address RAN3’s concerns.

**Q9: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We don’t have strong view, but be wondering if it’s problematic the handover requests of some UEs/IAB-nodes are accepted but some others are rejected, in case of non-bundling (i.e., the existing) messages.  |
| LG | We do not think group mobility is essential for enhancing IAB network performance. Group mobility would aim to solve the problem of signalling storm upon the change of topology, but we are not convinced if the problem is really severe or jeopardize the IAB network’s stability.  |
| Huawei | For group mobility, we agree to support this, i.e. migrating node and all/parts its child nodes/UEs migrate together as a group;For the bundling singling, the XnAP message and F1AP message, which are related to the IAB nodes within the migrating group, during the migration procedure can be bundled. Please note that R3 agreed: 1) all parent-child relations are retained at the new donor; 2) topology-related information should be made available to the new donor. This means the migrating IAB node and some its descendant nodes/UEs will migrate to the target CU **together as a topology/group**, and target should be aware of this topology. So, we anyway need the group mobility, but leave the group singling to be discussed by R3 mainly.**Purpose/benefit**: The group mobility itself is essential for the migration procedure. As to the group signalling, the purpose is to reduce the latency and overhead of multiple separate signalling.**Technical solution**: Design new XnAP and F1AP message as the grouped signalling.**Potential shortcomings**: N/A.**Specification effort**: New XnAP/F1AP procedure and message. |
| Samsung  | **purpose/benefit:*** The benefit is unclear. The transmitted information during migration cannot be reduced. The reduced part is only the number of messages. However, it may cause a lot of specification impact.

**technical solution:*** Group multiple UE contexts in the same message

**potential shortcomings*** We didn’t see clear benefit. We need first focus on the basic procedure by trying to reuse the existing signalling as much as possible. Such scheme looks like a further optimization.

**specification effort:**New messages are needed.  |
| Ericsson | In our view, it is a bit early to discuss such topic before assessing the real benefits and specification effort of “group mobility”. Additionally, since the IAB network is not mobile, there is no strong latency/performance requirement to move at once all IAB nodes/UEs involved in the migration. Hence, RAN2 should de-prioritize this topic. |
| Intel | Supporting message bundling may be complex and not that useful. For DL signalling, MAC multiplexing can be used for message bundling, and for UL messages, considering different UEs may complete HO at different times, multiplexing or bundling seems not efficient and not possible considering massive UE connecting within IAB network. |
| vivo | For group mobility, it is not necessary that the source CU integrates the handover requests of the all nodes in the migration network into one message block and sends it to target CU and the target CU integrates all handover commands into one message block and sends to the source CU. Too large message size shall be avoided to avoid potential NW instability due to high transport / processing capacity requirement.It is the duty of source CU to ensure that the respective handover commands of all nodes in the migration network has been received from target CU and delivered to all nodes in the migration network. Mechanism for proper delivery of handover commands by the source CU shall be studied instead. |
| ZTE | Message bundling has already been introduced in R16 IAB to reduce signaling overhead. For example, new F1AP/E1AP messages (i.e. IAB UP configuration update in F1, IAB UP TNL ADDRESS UPDATE in E1) are introduced in R16 IAB to update information for multiple UEs and child IAB-MTs which can be used in IAB node migration/RLF recovery scenarios for the purpose of signaling overhead reduction. In R17 IAB, it could be also applied to XnAP (e.g. handover request, handover request ack messages) and F1AP messages (e.g. UE context modification) for the same purpose as in R16 IAB.  |

### 2.2.10 Replace/avoid UE/child-MT RACH at inter-donor topology adaptation

Proposed by R2-2006625, R2-2007863

If rapporteur understands the above contributions correctly, this enhancement tries to avoid RACH for UE or descendant-node IAB-MTs during inter-donor migration. Such RACH would generally be considered necessary since the UE and descendant-node IAB-MT change their security association from the source to the target IAB-donor and therefore have to perform an RRC reconfiguration with resync. The proposal is that the RACH procedure of the resync could be avoided since the IAB-DU remains the same. The rapporteur is not certain what signalling would trigger the switch between the security associations, i.e., with what the RACH procedure would be replaced and what benefit this replacement would have.

Please address these issues in your comment.

**Q10: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We think the RACH-less handover was supported in LTE, so it could be assumed there is no significant issue here and the same solution is the baseline. We assume the UE/Child-MT avoids Msg1 and Msg2, so it starts from Msg3 (i.e., RRC Reconfiguration Complete). It’s beneficial to reduce the service interruption due to the handover procedure as considered in LTE.  |
| LG | It is too pre-mature to discuss this point at this stage. We can discuss it after making more progress about mobility enhancement. |
| Huawei | Agree to support the RACH less at decedent IAB MT/UE. Please note that the HO command (e.g. *RRCReconfiguration* including *reconfigurationWithSync* but no RACH resource) will still be sent to child MT/UE. Child IAB-MT still perform the RRC reconfiguration with resync, which will trigger the security change operation, but without MAC layer RACH.**Purpose/benefit**: The purpose is to reduce the latency caused by lots of RA procedure at almost the same time.**Technical solution**: Child MT/UE has the valid TA to its cell of parent node, since the parent-child relations are retained at the new donor. UL grant can also be allocated by parent DU as usual. Therefore, the MAC layer RA procedure can be saved during the inter-CU migration.**Potential shortcomings**: N/A.**Specification effort**: Minor updates to the reconfiguration with resync procedure. |
| Samsung  | * Purpose / benefit: RACH congestion might be avoided
* Technical solution: MT doesn’t do RACH during parent IAB node’s migration
* Potential shortcoming: security information change always needs the RACH operation, and this principle first needs to be broken. And also has the same understanding as rapporteur how the change of security parameters can be separated without RACH operation

Specification effort: RRC/MAC to describe the anchor node change without RACH. |
| Ericsson | It is not clear at the moment what is the issue with current legacy procedures. |
| Intel | It is not clear at this moment. For UE, as we still need to support legacy UE, we don’t see a need to change only for IAB scenario; For IAB-MT, considering number of IAB-MT is limited, the benefit of avoiding RACH may be limited. |
| vivo | RACH less handover could be beneficial to avoid RA storm and signalling overhead and should be supported. |
| ZTE | It is suggested to perform RACH-less handover for descendant IAB node/UEs since their parent node does not change. The switch between the security associations could be triggered by RRC reconfiguration with sync. It is beneficial to reduce the service interruption.  |

### 2.2.11 Local route selection beyond RLF

Proposed by R2-2007023, R2-2007200, R2-2007295, R2-2007840, R2-2008026, RAN3 agreements

RAN3 has already agreed that:

**Local re-routing scenario other than RLF can be discussed later or after RAN2 decision.**

As discussed in Rel-16, local rerouting tends to be suboptimal if the node has only local scope. Please describe how this issue would be addressed.

**Q11: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We assume the IAB-donor may configure the IAB-node(s) with some alternative routes, and the IAB-nodes may select one of them in case of the local re-routing. It leverages the topology-wide knowledge/optimization by the IAB-donor and the quick response/recovery by the local decision.  |
| LG | Even if one of main enhancement in IAB Rel-17 is to provide topological and path redundancy, just supporting path/topological redundancy is not enough and RAN2 should also study and develop the proper way to use this redundancy. We think that allowing local route selection beyond BH RLF would be the correct way not only to use topological and path redundancy efficiently but also to provide load balancing and resolve a DL congestion problem as well. Specifically, when the IAB node 1 receives a flow control feedback from the IAB node 3 to indicate a DL congestion problem toward the IAB node 4, even if the IAB node 1 has another route toward the IAB node 4, the IAB node 1 cannot forward the packet to the IAB node 2 because there is an entry matched to both BAP address and BAP path ID of the packet and no BH RLF on the link to the IAB node 3 occurs. In this condition, if the IAB node 1 holds all packets related to the flow control feedback until the congestion problem in the IAB node 3 is resolved, this may cause another congestion problem in the IAB node 1. But, if local re-routing is allowed before BH RLF occurs, the IAB node 1 not only reduce congestion problem in the IAB node 3 but also provide proper load balancing over the IAB network. For this, most of work would be RAN2. |
| Huawei | Agree to support the local re-routing for congestion mitigation or load balancing. The principle should be that IAB node will use the CU configured path based on the routing ID as in R16, unless some triggers (e.g. the RLF in R16 and other new conditions defined in R17) allow the IAB node to select the backup path (which is also configured by CU).**Purpose/benefit**: The purpose is to avoid UP data interruption or congestion caused by the cases other than RLF. For example, in case the primary BH link is congested but not under RLF yet, IAB node can switch the traffic to the backup BH link without any interruption to the traffic transmission.**Technical solution**: discuss the new cases other than RLF to trigger the local re-routing. For the re-routing itself, R16 BAP spec can be reused.**Potential shortcomings**: N/A.**Specification effort**: Minor updates to the routing performed at BAP layer. See no impact on the configuration. |
| Samsung  | * Purpose/benefit: to be more reflective on latency and load level routing
* Technical solution: IAB node can reroute by itself with some configuration from CU when other condition (load balancing /latency reduction/scheduling enh is needed) happens.
* Potential shortcomings: related specification is necessary.

Specification effort: mainly BAP spec needs to resolve this routing operation. |
| Ericsson | We agree that RAN2 discusses whether local routing could be beneficial for other scenarios, such as link congestion while ensuring no undesirable effect of these local decisions on the other IAB nodes of the network. |
| Intel | Yes, we support local re-routing scenario other than RLF should be discussed and supported in Rel-17. IAB network can consider both topology-wide (centralized) routing and local re-routing as local re-routing can bring flexibility to IAB network in following aspects: 1) traffic congestion 2) QoS enhancement 3) topology fairness, etc.  |
| vivo | Local rerouting could be helpful to solve temporal local congestions and we shall support it. |
| ZTE | It is suggested to consider the local re-routing due to latency consideration. In order to satisfy the PDB requirement of packets, the IAB node could be able to measure and report the experienced delay per BH RLC channel to IAB-donor-CU, the IAB-donor-CU may estimate the accumulated latency for different routing paths based on the one hop latency per BH RLC channel report and configure appropriate routing paths for DL/UL backhaul traffic.When the intermediate IAB node detects that the original path associated with the data packet could no longer satisfy the PDB requirement of the data packet, the intermediate IAB-node may check if other backup path could satisfy the PDB requirement and then re-route the data packet to the backup path. |

### 2.2.12 Multiple routes with route priority

Proposed by R2-2006624, R2-200720

This topic was considered during early Rel-16 discussions on routing and never followed up anymore.

**Q12: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

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| **Company** | **Comment** |
| Kyocera | We think this topic can be considered together with Q11 (i.e., Local route selection beyond RLF). We assume the route with the smallest number of hops should be prioritized but the route priority is up to IAB-donor configuration  |
| LG | We think that this enhancement is minor optimization and needed only when local rerouting is allowed other than BH RLF. If local rerouting is performed only after BH RLF as in Rel-16 IAB, gains of this enhancement is very limited and may be not meaningful. Thus, it is better to discuss the local rerouting or route selection issue first and then we can come back to discuss this issue after RAN2 determines something on local rerouting issue. It is also expected that if we do on this issue, most of work may be charged in RAN2. |
| Huawei | Before we agree anything, we need ensure this does not conflict with the R16 BAP routing architecture (based on routing ID configured by CU rather than based on the routing entry priority).We need to clarify if this is only used in case of local re-routing.Need more clarification on the proposal before we provide views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate. |
| Samsung  | * Purpose / benefit: to respond swiftly on the local situation of channel, load, latency status etc
* Technical solution: donor CU configures the priority on each possible paths, and gives the related condition. IAB node follow this configuration
* Potential shortcomings: related specification is necessary

Specification effort: mainly BAP spec needs to resolve this routing opration.  |
| Ericsson | During Rel-16, RAN2 didn’t find any real benefits of multiple routes with route priority. Hence, the proponents of route priority should highlight why it is worth the effort to discuss in Rel-17. |
| Intel | No, path priority can be various considering different scenarios, it’s hard to set a common priority criterion, considering throughput/latency/QoS/fairness/etc. |
| vivo | Not sure what does priority mean. The current routing scheme implicitly support two priorities: the desired route to destination and other route that can reach the same destination. If the route of the highest priority is always selected, there is no need to introduce route priority.We prefer not to introduce route priority. |
| ZTE | We also think this question can be pending on the progress of Q11. Whether priority or other routing metric should be considered depends on what kind of re-routing scenario is supported.  |

### 2.2.13 Inter-donor-DU rerouting

Proposed by R2-2007865, RAN3 agreement

RAN3 has already agreed that:

**Inter-Donor-DU re-routing can be discussed later or after RAN2 decision.**

RAN3 precluded inter-donor-DU rerouting during Rel-16 since this could create packet discard on the wireless network as the source IP address of the rerouted packet would not be compliant with the address pool of the local subnet.

Please address this issue in your comment.

**Q13: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Kyocera | We don’t have strong view on this topic.  |
| LG | The inter-Donor-DU re-routing is to retransmit the buffered BAP PDUs to the new donor-DU after intra-donor topology or inter-donor topology update, but this requires to change the carried BAP routing ID which is not allowed for re-routing even after BH RLF in Rel-16 IAB. In addition, in inter-donor topology update case, even though the packets containing PDCP PDUs is successfully retransmitted to the new donor-CU, these PDCP PDUs may be discarded because the applied security configuration is different the at the new donor-CU. This means that radio resource is wasted. We think that simple approach is to rely on upper layer retransmission mechanism, e.g., TCP or application level retransmission.  |
| Huawei | Agree to support the inter-donor-DU rerouting.We intend to solve this for the case of intra-/inter-CU migration.For the packed discard issue at new donor-DU, as mentioned by rapporteur, one example is that new donor-DU does not apply the “IP address filer” during the period of migration.**Purpose/benefit**: The purpose is for data lossless, which is more like to fix the R16 leftover/bugs. In R17, once we have the intra-/inter-CU migration, the destination donor-DU (i.e. destination BAP address) may change. The UE’s traffic may be lost once the data has been added with the BAP header, which is not allowed to be modified, even in case the destination donor-DU has changed.**Technical solution**: In R17, the BAP routing ID in the BAP header should be allowed to be modified, so that the BAP data during the migration period can be routed to the new donor-DU.**Potential shortcomings**: N/A.**Specification effort**: To specific how to route the on-the-air data to the target donor DU and how to avoid the data being discarded at target donor DU due to the source IP address filer. |
| Samsung  | **purpose/benefit:*** During inter-donor-DU migration, such inter-donor-DU rerouting can help to anchor the packets transmitted via the source path to the source donor CU even if the donor DU is changed. Thus, we think such inter-donor-DU re-routing can avoid packet loss

**technical solution:*** Source IP filtering enhancement at the target donor DU, e.g., avoid discarding the packets with the source IP address at the source path

**potential shortcomings:*** Need enhancement to overcome the source IP filtering at the donor DU.

**specification effort:*** F1AP enhancement inside donor.
 |
| Ericsson | In our view, RAN3 should solve the issue of packet discard for inter-donor-DU rerouting before any discussion on this topic in RAN2. |
| Intel | We think this can be left to RAN3 discussion |
| vivo | We don’t prefer inter-donor rerouting in Rel-17 as the rerouting is complex. We can just rely on TCP retransmission for simplicity. |
| ZTE | Inter-donor DU re-routing is beneficial to avoid data packet loss in topology adaptation or BH RLF recovery scenario. However, to support this feature, the ingress IP filtering in the routers between the new donor DU and the new donor CU should be disabled. |

### 2.2.14 IAB-specific admission control during RLF recovery

Identified in RAN3 discussion

The main idea is to give IAB-MT’s priority over UEs in admission control during RLF recovery. Please describe in more detail how this could be accomplished.

**Q14: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Kyocera | We have no strong view, but tend to think we should wait for more information from RAN3.  |
| LG | Not prefer to discuss this issue in this email discussion and want to wait more RAN3 progress.It’s too early to figure out clearly what the RAN3 identified issue and we also think it is not urgent from RAN2 point of view and the RAN2 discussion/conclusion may be different depending on RAN3 decision/progress. Thus, we would like to discuss other RAN2 originated issues first, which are based on the contributions submitted in the last RAN2 meeting and it would be better to wait RAN3 progress on it and then RAN2 can start to discuss this issue based on more concrete RAN3 conclusion/progress. |
| Huawei | No strong view, but not clear on the purpose.In R16, we agreed there is no need of early IAB indication than Msg5. We need to clarify why there is no need to prioritize the IAB during RRC connection setup but there is the need in RRC re-establishment case. |
| Samsung  | This scheme is unclear to us. If the intention is to give IAB-MT’s priority over UEs in admission control during RLF recovery, it sounds a potential enhancement. However, before we have technical discussions, we need some more information about this scheme.  |
| Ericsson | Admission control is not a RAN2-driven topic. So RAN2 can wait progress in RAN3 before discussing, if needed, this issue. |
| Intel | It will be nice to quote the RAN3 discussion text, or at least under which agenda item was found for RAN2 to better capture the discussion.We think differentiation between priority of IAB-MT and UE is not essential. RLF recovery can be prioritized over regular access any time, whether further prioritization is necessary is not clear to us. |
| vivo | Good NW implementation shall be able handle this, e.g., to prioritize IAB re-establishment over UE access. |
| ZTE | It is suggested to first clarify this scenario and given more details. Or we can wait for RAN3’s progress. |

### 2.2.15 Sending F1AP configuration information via RRC

Identified in RAN3 discussion

The main idea is to avoid F1AP reconfiguration signalling handshakes by including the information in the handover command, for instance.

**Q15: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Kyocera | We’re wondering if RAN2 should wait for RAN3’s progress.  |
| LG | Not prefer to discuss this issue in this email discussion and want to wait more RAN3 progress.It’s too early to figure out clearly what the RAN3 identified issue and we also think it is not urgent from RAN2 point of view and the RAN2 discussion/conclusion may be different depending on RAN3 decision/progress. Thus, we would like to discuss other RAN2 originated issues first, which are based on the contributions submitted in the last RAN2 meeting and it would be better to wait RAN3 progress on it and then RAN2 can start to discuss this issue based on more concrete RAN3 conclusion/progress. |
| Huawei | We need to first clarify the proposal on what is the “F1AP reconfiguration signalling handshakes” and how can it be saved by included in RRC. |
| Samsung  | To support CP-UP separate, NR RRC will be enhanced to include the F1AP message in the NR RRC as a container. However, I am not sure if it is beneficial to include F1AP message in some other RRC message, e.g., HO Command. Normally, I would like to separate the F1AP transmission from the RRC message. The reason is that in Rel-16, F1AP message is always transmitted via BH RLC CH. I don’t think breaking such principle is a good practice. **purpose/benefit:*** The benefit is unclear to us

**technical solution:*** As described above

**Potential shortcomings:*** Break the basic design in Rel-16, i.e., F1AP via BH RLC CH

**specification effort:**Include F1AP in other RRC messages, e.g., HO CMD. |
| Ericsson | This is a RAN3 topic. So RAN2 can wait progress in RAN3 before discussing, if needed, this issue. |
| Intel | We think this can be left to RAN3 discussion, and RAN2 further enhance RRC signalling if there’s any RAN3 agreement. |
| vivo | Not sure if it is the right way to tightly couple the F1-AP reconfiguration signalling with RRC signalling. There could be many ways (e.g.old BAP address or node ID) to identify for which IAB node the F1-AP reconfiguration message is. We can discusses the solutions later after RAN3 progress.  |
| ZTE | Sending F1AP configuration information via RRC (e.g. handover command) is beneficial to reduce service interruption in inter donor migration scenario. For example, NCGI, routing and traffic mapping information configured by target donor CU could be sent by target donor CU to source donor CU in advance via RRC in handover command during handover preparation phase.  |

### 2.2.16 Conditional packet duplication

Proposed by R2-2008025,

Conditional packet duplication is expected to increase robustness of the IAB networks. It would be also useful to decrease latency. To maximally utilize path diversity, it should be possible for conditional packet duplication to occur at the intermediate nodes over the routing path, not limited to the originating/source node. For this reason, packet duplication functionality should be located at BAP.

**Q16: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| LG | We think that it is worthwhile to discuss packet duplication at BAP entity to overcome packet loss and increase reliability after BH RLF.One important issue is that conditional packet duplication should be triggered in a strictly controlled manner to avoid packet flooding in the IAB networks. This requires investigation on the triggering condition of duplication, selection of target packet flows allowed for duplication. |
| Ericsson | PDCP packet duplication is already possible and, with proper route ID setting and good implementation, it could be achieved that those packets follow different path. Nevertheless, packet duplication has a high cost in terms of resource consumption. For this reason, that should not be used as general solution to increase robustness, rather as a feature that can be beneficial only for certain specific types of traffic requiring high reliability and low latency.Also the standardization effort might not be trivial. That will affect the BAP, which will have to support at least functionalities for duplication execution, duplicates detection/discard. Also new BAP control signalling might be needed to indicate to child nodes that duplication is activated/deactivated. Besides, also the MAC layer will be affected since it has to ensure that the duplicates have to be mapped to separate carriers, as it happens in the legacy PDCP duplication. If then the intention is to even support BAP duplicates transmissions towards different links/childs, then there is the risk that a high amount of duplicates are unnecessarily traversing different “branches” of the IAB network, which is certainly not desired from performance perspective |
| vivo | PDCP duplication can be used if necessary. Not sure if we have enough resource to discuss the new duplication scheme.  |
| ZTE | It is suggested to only consider the PDCP duplication of UE instead of IAB node.  |

### 2.2.17 Topology Establishment Enhancement

Proposed in R2-2006947,

Improve IAB topology establishment efficiency by considering IAB node integration sequence can help to reduce complexity of handover as well as reduce burden of topology reorganization and optimization. Hence, we propose that IAB node selects another IAB node or an IAB donor as a parent only if the RSRP of the IAB node or IAB donor exceeds a threshold (which is provided in system information). The threshold is successively decreased in steps to allow all IAB nodes to integrate into the network. Meanwhile, techniques to ensure that the number of hops to an access IAB node is limited should be considered.

**Q17: Please provide your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | Current topology node integration is highly dependent on the chosen sequence for activation of IAB nodes. To reorganize an inefficient topology towards a more efficient topology, the network needs to perform handovers in very specific sequences. Determining the sequences of such handovers is non-trivial and managing the complexity of such sequences of handovers can be challenging. An initial topology that is efficient can significantly reduce the burden of topology reorganization and optimization for network operators. |
| vivo | Topology adaption from the perspective of topology optimization can be achieved via migration procedure which is already in the WI scope. Some cell search procedure may cause additional standardization effort. |
|  |  |

### 2.2.18 Other enhancements

**Q18: Please propose other enhancements. Please include your views on purpose/benefit, technical solution, potential shortcomings and specification effort for this enhancement candidate.**

|  |  |
| --- | --- |
| **Company** | **Enhancement proposed** |
| Kyocera | We think the lossless delivery over hop-by-hop RLC ARQ becomes more important in Rel-17, which was studied as in section 8.2.3 of TR 38.874. We assume the IAB-DU may delay RLC ACK to its child nodes by implementation, but think Stage-2 should capture the outline of how to achieve the end-to-end reliability over multi-hop network.  |
| Huawei | R2 impact for **inter-CU RLF recovery** (not enhancement but the basic procedure)RAN2 needs to discuss the behaviours of the descendent IAB-nodes/UEs of the IAB-node recovering to a new IAB-donor-CU, in the following two aspects: 1) How can descendent IAB-nodes and UEs be aware of the CU change? 2) Whether descendent IAB-nodes and UEs should migrate/re-establish to the new IAB-donor-CU together with the recovering IAB-node? |
| vivo | Intra-frequency DC needs to be discussed from the perspective of inter-CU migration. It seems feasible to introduce intra-frequency DC to create redundant route for migration in Rel-17. For intra-carrier DC, the major standardization work is in RAN1 for radio aspects. The RAN2/RAN3 protocols for inter-carrier DC can be just reused. It is FFS which aspects shall be enhanced from RAN2/3 later on. |

# Phase 2

# Conclusion

# References

1. RP-201293: WID for NR\_IAB\_enh; TSG RAN Meeting #88, Electronic Meeting, June 29 - July 3, 2020

# Annex: RAN3 agreements from R3#109e

## 13.2. Topology Adaptation Enhancements

### 13.2.1. Inter-Donor IAB Node Migration

**Inter-donor migration due to load balancing and RLF recovery may use the same signaling, where additional procedures and signaling, specific for each of the use cases, are possible.**

**The following cases for inter-donor migration are studied:**

**a) IAB-MT is migrated between IAB-donors.**

**b) IAB-MT is simultaneously connected to two IAB-donors**

**c) IAB-DU is simultaneously connected to 2 donor-CUs (common understanding is that we won’t break F1 interface principles)**

**d) IAB-MT performs RLF recovery at new IAB-donor.**

**How to achieve b)?**

I) IAB-MT simultaneously connected to 2 donors;

**-> How to achieve I)?**

II) IAB node simultaneously connected to 2 donor-CUs.

**-> How to achieve II)?**

**When evaluating the solutions for inter-donor migration, the following aspects should be considered:**

**- the ability to avoid service interruption,**

**- the ability to avoid signaling storm caused by the migration,**

**- the incurred processing load caused by the migration (clarification: simultaneous migration of all affected devices causes more processing load than gradual migration),**

**- the complexity of the solution,**

**- the specification impact**

**The migration mechanism should allow to migrate to another donor all or some devices (the IAB nodes and/or UEs directly or indirectly served by the top-level IAB node).**

**We assume that all parent-child relations are retained at the new donor**

**(common understanding that this also includes UEs)**

**UEs and IAB-MTs should not be forced into connection re-establishment in order to migrate to a new donor**

**(common understanding that the network shall not force disconnection)**

The inter-donor migration solutions where IAB nodes maintain simultaneous connections to both donors are enabled.

**The following information should be made available to the new donor:**

**1. Contexts of all involved UEs,**

**2. Contexts of all involved MTs,**

**3. Contexts of all involved DUs,**

**4. Backhaul and topology-related information,**

**5. IP address information**

**Current signaling is taken as baseline for inter-donor migration of UEs and IAB-MTs**

**(common understanding is that we shall consider reducing the associated signaling load)**

**The approach where IAB-MT migration uses separate procedure from the ones used for migration of the collocated IAB-DU and the served UEs and MTs is adopted as baseline.**

**As baseline, IAB-MT migration should use a separate procedure w.r.t. the migration of the co-located IAB-DU, the served UEs and the served MTs**

### 13.2.2. Reduction of Service Interruption

**Topological redundancy should be considered as one mean among others for service interruption reduction.**

**CHO should be supported for IAB-MT.**

Chair: unless excluded, normally current functionality is applicable

**We shall consider how to reconfigure descendant nodes in order to reduce service interruption during migration**

**Discuss mitigation of packet loss and reduction of unnecessary transmissions during IAB-node migration.**

### 13.2.3. Topology Redundancy

**Consider Scenario 1 and 2 for CP/UP separation:**

**Scenario 1: F1-C via M-NG-RAN node (non-donor node) + F1-U via S-NG-RAN node (donor node)**

**Scenario 2: F1-U via M-NG-RAN node (donor node) + F1-C via S-NG-RAN node (non-donor node)**

**Analyze Scenario 1 and Scenario 2 for inter-Donor Topology Redundancy, with the principle that an IAB-DU only have F1 interface with one Donor-CU:**

**Scenario 1: the IAB is multi-connected with 2 Donors.**

**Scenario 2: the IAB’s parent/ancestor node is multi-connected with 2 Donors.**

**Routing Enhancement via descendant node can be discussed later or after RAN2 decision.**

**local re-routing scenario other than RLF can be discussed later or after RAN2 decision.**

**inter-Donor-DU re-routing can be discussed later or after RAN2 decision.**

**Deprioritize Multi-Route Support with data split in IAB.**

**Multi-MT Support is FFS in RAN3 pending RAN2**