**3GPP TSG-RAN WG3 #111-e R3-211003**

**25 January – 4 February 2021**

**Online**

Agenda Item: 13.2.2

Source: Nokia (moderator)

Title: Summary of email Discussion on Reduction of Service Interruption reduction

Document for: Approval

# Introduction

**CB: # 36\_IAB\_Reduction\_of\_SrvInt**

**CATT**

**Parent node reconfigures itself until it receives a RRC reconfiguration complete message from child node.**

**Introduce an indication message to child node to trigger TNL redirection procedure after parent node migration complete.**

**consider the TNL redirection procedures for all IAB nodes go on simultaneously.**

**Extend Xn HO req message to a per topology signaling to request the migration of all IAB nodes and UEs.**

**Introduce ctxt list in migration request message.**

**Ctxt list includes:**

**- ctxt of migrating IAB node and its descendant node(s)**

**- UE ctxt of UE(s) under the migrating IAB node**

**- UE ctxt of UE(s) under the descendant node(s) of migrating IAB node**

**consider other signaling to replace the ctxt setup procedure for child nodes and UEs between parent nodes and target CU.**

**consider the enhancement to reduce packet loss and unnecessary transmission.**

**SS**

**to support DL transmission over the source path, IAB-MT part can keep the BAP layer related configurations (e.g., BAP address, BH RLC CH configuration, IP address of the source path) and the F1-U tunnels over the source path on per-BH RLC CH basis.**

**IAB-DU can delay transmission of RRCReconfiguration message when certain condition is satisfied, e.g., success RACH at top level migrated node, receive RRCReconfiguration message by the collocated IAB-MT at the descendant node(s).**

**legacy CHO procedure can be reused, and the IAB donor CU can balance the fast recovery and resource reservation by implementation.**

**to combat the UL packet loss, the UL DDS can be applied when the inter-donor-DU re-routing is not applicable, and the enabling of UL DDS can be configured to the IAB node to enabling the packet buffering.**

**to avoid the unnecessary transmission of DL packets, the IAB node can keep the old configurations at source path till the final on-the-fly packet indication is received.**

**QC**

**revisit descendant-node reconfiguration before IAB-MT handover due to potential failure conditions.**

**discuss viable procedures for descendant-node reconfiguration via source path.**

**discuss procedures for concurrent TNL migration of all descendant nodes during intra-donor topology adaptation to reduce interruption time.**

**Extend the NR-UP protocol to support uplink data delivery status reports to enable recovery of packet loss during intra-donor migration.**

**consider local rerouting to reduce packet loss in intra-donor topology adaptation.**

**liaise RAN2 on the local rerouting to reduce packet loss in intra-donor topology adaptation.**

**Intel**

**Immediately upon receiving the RRCReconfiguration message from source path, the parent IAB node should stop granting further UL transmission to its descendant node**

**Fuj**

**consider the following options for F1AP enhancement:**

**- Indicating to migrating node to reuse the old context as the new context of UEs/child IAB-MTs during F1 setup procedure; or**

**- Indicating to migrating node to reuse the old context as the new context of UEs/child IAB-MTs by UE context modification procedure.**

**RRC indication should help the migrating node to differentiate whether the TNL address added is for old F1-C or new F1-C.**

**Nok**

**discuss whether the conditional RRC message delivered via the source path is stored in the migrating IAB-DU or delivered to descendant IAB-nodes.**

**use MOBIKE to reduce the service interruption during inter-Donor-DU topology adaptation.**

**HW**

**In Rel-17, IAB-node still perform RRC Re-establishment for BH RLF recovery.**

**take the procedure shown as a baseline for the inter-CU BH RLF recovery.**

**study the mechanism for IAB-DU recovery (e.g. F1 connection re-establishment, rather than setup) in inter-donor-CU RLF recovery case, to avoid signaling storm in F1 interface between IAB-DUs and new IAB-donor-CU and avoid long term service interruption for connected UEs.**

**discuss behaviors of the descendent IAB-nodes/UEs of the IAB-node recovering to a new IAB-donor-CU via new path, in the following two aspects:**

**- How can descendent IAB-nodes and UEs be aware of the CU change?**

**- Whether descendent IAB-nodes and UEs should re-establish to new IAB-donor-CU with the recovery IAB-node?**

**AT&T**

**A new F1AP-based IAB parent migration indication should be introduced, possibly as part of the CU to DU RRC Information IE to be used for indication of parent IAB node migration to descendant nodes.**

**The proposed F1AP-based IAB parent migration indication should be used to trigger buffering of RRCReconfiguration at the parent IAB-DU of descendant IAB node.**

**The RRCReconfiguration message buffered at the parent IAB-DU of descendant IAB node should be released and delivered when the IAB-MT collocated with the parent IAB-DU of descendant IAB node receives its own RRCReconfiguration message.**

**Discuss procedures to perform concurrent migration of F1 associations of descendant IAB nodes to new TNL addresses along the target path after successful RRC reconfiguration of descendant IAB nodes to reduce service interruption time.**

**ZTE**

**Rel-16 re-routing mechanism is reused in intra-donor DU migration scenario.**

**If inter-donor DU local re-routing is not applicable, the solution of re-transmitting by UE (e.g. delayed RLC status) or re-transmitting by access IAB node (e.g. UL DDS) could be considered.**

**the procedure given is taken as baseline for inter-CU BH RLF recovery.**

**introduce a new XnAP procedure for transmitting the IAB-DU context and F1AP UE context, which is stored at the old IAB-donor-CU from the old IAB-donor-CU to the new IAB-donor-CU.**

**same mechanism is used in both inter-donor migration and RLF scenario to F1-C migration between the migrating/recovery IAB-DU and the target/new donor CU.**

**determine which procedure (RRC Re-establishment or HO) is baseline for updating AS security for descendant nodes of the IAB-node performing inter-CU recovery and consider above options as candidates to update AS security for descendant nodes.**

**E///**

**study solutions for inter-donor RLF recovery, where resource reservation is not done in advance.**

**To avoid packet losses and, consequently, unnecessary UL/DL transmissions during migration, IAB nodes may be provided with the new configuration/actions which is/are executed when an indication (e.g. via BAP or F1AP) is provided to the IAB nodes.**

**\*\*\*\*\***

**- XnAP aspects: ctxt list in XnAP message? (“group HO”?) New XnAP procedure?**

**- F1AP aspects: migration indication?**

**- Behavior w.r.t. reception of RRC reconfiguration?**

**- Any UP aspects?**

**- How to update AS security info to descendants?**

(Nok - moderator)

Summary of offline disc [R3-211003](file:///C%3A%5Ctemporary%5CRAN3%5CRAN3%20Jan21%5CCB%20discussions%5CCB%2036_IAB_Reduction_of_SrvInt%5CInbox%5CR3-211003.zip)

The discussion has two phases:

Phase 1: Enhancements to IAB service interruption (and others) to be discussed in Rel-17

Phase 2: TBD

The deadline for Phase 1 is Thursday, Jan 28th, 12:00 UTC. This allows us to have some further discussion based on the 1st round feedback and discuss intermediate stage in Monday online session. We might be able to already achieve some agreements at this stage.

The deadline for Phase 2 is the same as for all email discussions, i.e., Tuesday, Feb 2nd, 12:00 UTC.

# For the Chairman’s Notes

Propose the following:

**Agree following proposals:**

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**Continue discussion on following:**

# Discussion

## High-level aspects for Reducing Interruption Time for Intra-donor Topology Adaptation

Contribution ([3]) discuss Rel-16 migration procedure “Rel-16 IAB indicates that the steps of performing RRC Reconfiguration and switching F1-C connections and F1-U tunnels to new TNL addresses can be performed by the descendant IAB-nodes *after* or in *parallel* with the handover of the migrating IAB-node.”

* Observation 1: The bottom-up procedure for reconfiguration of the descendant nodes before IAB-MT handover may incur large delays if the TNL migration is attempted before the target path becomes available.
* Observation 2: The nested procedure for reconfiguration of the descendant nodes before IAB-MT handover may incur large delays if the TNL migration is attempted before the target path becomes available.

Contribution ([3][8]) propose to discuss procedures for **concurrent TNL migration of all descendant nodes during intra-donor topology adaptation to reduce interruption time**.

**Q1: Please share your view on using concurrent TNL migration of all descendant nodes during intra-donor topology adaptation to reduce interruption time.**

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| **Company** | **Comment** |
| QC | Yes, concurrent TNL migration of all descendant nodes may significantly reduce interruption time and should be discussed.  |
| Samsung  | Yes. Precisely speaking, it should be **nearly concurrent TNL migration**.  |
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**Summary:**

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**Potential Proposal:**

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## Transfer RRCReconfiguration for descendant IAB over source path

Last meeting agreed:

The RRCReconfiguration to the descendant IAB can be transferred via the source path, i.e. before the migrating IAB detach from source parent cell.

Contribution ([2][3][8]) propose the RRCReconfiguration is buffered in the parent DU and the parent DI deliver the buffered RRC message to child IAB when a condition is satisfied (e.g. when the migrating IAB connect to target parent).

Contribution ([6]) propose to also consider another option that the RRCReconfiguration is buffered in the descendant IAB, and the buffered RRC message is executed only when a preconfigured condition is satisfied (e.g. when the migrating IAB connect to target parent).

* Solution 1: the RRCReconfiguration for the child IAB is buffered in the parent DU, and it is only sent to the child IAB when a precondition is satisfied.
* Solution 2: the RRCReconfiguration for the child IAB is buffered in the child IAB-MT, and it is only executed when a precondition is satisfied.

Following aspects need to be considered:

* In Solution 1, how does the parent DU know which RRCReconfiguration message should be buffered?

Contribution ([8]) proposes Donor-CU includes an indication in the F1AP message, to inform the parent DU that the *CU to DU RRC Information* IE contains an RRCReconfiguration message that needs to be buffered due to an upstream IAB node migration.

* How to handle the buffered RRCReconfiguration in case the migration of the parent node fails?

For Solution 1, Contribution ([3]) proposes 2 options: 1) **Option 1**: Release the child node’s buffered RRC Reconfiguration message to the respective child node. The released message may carry an obsolete configuration which will be overwritten by the BH RLF recovery procedure. 2) **Option 2**: Forward a buffered dummy message to the child node and discard the child node’s buffered RRC Reconfiguration message. The dummy message carries the same PDCP SN as the child node’s buffered RRC Reconfiguration message and is received from the IAB-donor-CU as part of the same F1AP message as the child node’s RRC Reconfiguration message. A child node that receives a dummy message may further release a dummy message for its own grand-child node. This needs RAN2 feedback.

For Solution 2, this may need to be discussed in RAN2.

* What happens if Donor-CU wants to send another RRCReconfiguration message to the descendant IAB-MT while the RRCReconfiguration message due to parent IAB-node migration is still pending?

**Q2-1: Please share your view on how to deliver the RRCReconfiguration for descendant IAB via source path (e.g. solution 1, or solution 2, or any other solution).**

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| **Company** | **Comment** |
| QC | Both solutions work for INTRA-donor migration.For solution 1, the release of the RRC Reconfiguration messages creates a hop-by-hop indication that triggers the TNL migration at the next-tier nodes, which is very fast.For solution 2, a separate indication has to be defined to trigger the application of the new configuration at the child IAB-MT in order to achieve the same purpose.NOTE: Solution 1 can also be applied to UEs for INTER donor migration. Solution 2 can NOT be applied in this case. |
| Samsung | We prefer to Solution 1. As analyzed by QC, solution 1 is fast and can be applied for both intra-/inter- donor migration. Moreover, solution 1 introduces less impact, which is only in RAN3.  |
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**Q2-2: Please share your view on the impact to RAN3, e.g.**

* **For Solution 1, it requires new indication in F1AP message, etc.**
* **For Solution 2, any impact to RAN3?**

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| **Company** | **Comment** |
| QC | Solution 1 needs indicator in F1AP.Solution 2 needs an indicator in RRC. Solution 2 also needs an additional L2 message to kick off RRC execution. This requires RAN2 input. |
| Samsung | Agree with QC. The impact of solution 2 is in RAN2 scope |
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For Solution 1, Contribution ([2]) proposes the condition for sending the buffered RRCReconfiguration message could be:

* In the migrating IAB, the condition could be when the migrating IAB completes the RACH.
* In the descendant IAB, the condition could be when the IAB receives its own RRCReconfiguration. For example, when IAB2 receives its own RRCReconfiguration, IAB2 send the buffered RRCReconfiguration to its child IAB (e.g. IAB3).

Contribution ([1]) proposes “Parent node reconfigures itself until it receives a RRC reconfiguration complete message from child node.” This seems indicate the descendant IAB only execute the RRCReconfiguration after the child IAB completes the Reconfiguration.

For Solution 2, since the descendant IAB-node is not aware when the parent IAB-node has successfully connected to the target, a new indication from the parent DU to descendant IAB-node has to be introduced. This indication could, for instance, be a BAP control PDU. The condition to execute the buffered RRCReconfiguration could be the reception of the indication from parent node.

**Q2-3: Please share your view on the condition (i.e. the condition to send the buffered RRCReconfiguration and when execute the RRCReconfiguraiton in Solution 1, the condition to execute the buffered RRCReconfiguration in Solution 2)**

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| **Company** | **Comment** |
| QC | Solution 1: The migrating IAB-node should send the buffered RRCReconfiguration AFTER successful RA procedure, and the descendent nodes should send the buffered RRCReconfiguration AFTER reception of the RRC Reconfiguration from its parent node. The RRCReconfiguration should be executed upon reception.Solution 2: The migrating IAB-node should send the L2 indication AFTER successful RA procedure, and the descendent nodes should send the L2 indication AFTER reception of the L2 indication from its parent node. The RRCReconfiguration should be executed upon reception of the L2 indication. |
| Samsung  | Agree with QC |
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**Indication to descendant IAB**

Contribution ([1]) propose to introduce an indication message to child node to trigger TNL redirection procedure after parent node migration complete, e.g. Step 14 and 16 in below figure.



Figure 1 Intra-CU migration for reducing service interruption

**Q2-4: Please share your view on the indication to descendant IAB**

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| **Company** | **Comment** |
| QC | The indication in this figure represents the L2 indication of solution 2.The procedure shown in Figure 1 is a bottom-up procedure. Note that this procedure ONLY works with solution 2. The float chart is NOT correct: Step 5 should occur AFTER step 16, and step 8 should occur AFTER step 14. Note that the nested procedure works with both, solution 1 AND solution 2. |
| Samsung | Agree with QC’s analyze. The idea of this indication is aligned with the solution 2. So, we don’t need a separate discussion for this.  |
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**Summary:**

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**Potential Proposal:**

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## UL Packet loss and unnecessary transmission

During inter-Donor-DU migration, some UL/DL packets may be lost.



Figure 1:Packet loss during intra-donor migration: 4a: Packet loss in downlink, 4b: Packet loss in uplink

For DL, donor CU can discover the packet loss via current DDDS or PDCP status report, and recover the packet loss via retransmission. There may be no need for any enhancement.

For UL:

* Contribution ([2][3]) propose to introduce an uplink version of the F1-U DDDS (UL DDS).
* Contribution ([1] [3] [9]) proposes to also consider re-routing.
* Contribution ([9]) proposes the solution of re-transmitting by UE (e.g. delayed RLC status) or re-transmitting by access IAB node (e.g. UL DDS) could be considered, if re-routing is not applicable.
* Contribution ([10]) proposes IAB nodes may be provided with the new configuration/actions which is/are executed when an indication (e.g. via BAP or F1AP) is provided to the IAB nodes.

The unnecessary transmission is related to the “on-the-fly packets are buffered at the intermediated nodes towards the destination”. If these packets are transmitted after the migration, they may be discarded. It may waste the resource if continuous the transmission for the related packets.

* Contribution ([2]) propose the IAB node can keep the old configurations at source path till the final on-the-fly packet indication is received, to avoid the unnecessary transmission of DL packets.
* Contribution ([4]) proposes “Immediate upon receiving the RRCReconfiguration message from source path, the parent IAB node should stop granting further UL transmission to its descendant node.”
* Contribution ([10]) proposes IAB nodes may be provided with the new configuration/actions which is/are executed when an indication (e.g. via BAP or F1AP) is provided to the IAB nodes.

**Q3: Please share your view on how to address the UL packet loss, and unnecessary transmission?**

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| **Company** | **Comment** |
|  | QualcommUL packet loss can be mitigated using UL DDS which has the same merits as DDDS. As DDDS, UL DDS relies on packet loss for packet recovery.Local rerouting avoids unnecessary transmissions by reducing packet loss assuming packets are not filtered at the target-path donor DU. This means that local rerouting may NOT always work for inter-donor-DU migration.The F1AP or BAP indicator needs more discussion. It could be combined with the RRC Reconfiguration discussed in solution 2 above (section 3.2). In solution 1, the parent node could send a L2 indicator to the child node to stop UL transmission as soon as it has received and buffered the child’s RRC Reconfiguration message. |
| Reducing grants for UL transmission is up-to-implementation.Samsung  | For UL packet loss:UL DDS and inter-donor re-routing can solve the problem. If inter-donor re-routing is always available, UL DDS may not need. However, this requirement cannot be always guaranteed. So, we need UL DDS as well when inter-donor re-routing is not available, i.e., * Inter-donor re-routing
* Configurable UL DDS, i.e., configure to use UL DDS if inter-donor re-routing is not available.

For unnecessary transmission The intention is to deal with the on-the-fly packets buffered at the migrated IAB node and its descendant node(s). Moreover, we need discuss it for DL and UL separately.  For DL, each of those node should keep the configuration of the source path. When to release those configurations is determined by when the final packet from the source path is received. Thus, a *final on-the-fly packet indication* needs to be sent to the IAB node.  For UL, the on-the-fly packets contain the old source IP address, old BAP routing ID. The old source IP address cannot be updated since IAB node protocol stack indicates that IP layer processing is not allowed. To solve this problem, the configurable UL DDS or inter-donor rerouting can work. The old BAP routing ID may not be routable in the target path. To solve this problem, either updating BAP routing ID or a default BAP routing for all packets without matched routing entry can be applied.  |
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**Summary:**

**Potential proposal:**

## MOBIKE

Contribution ([6]) propose to use MOBIKE (RFC4555) to reduce the interruption. Rel-16 Intra-CU migration is shown in below call flow.



Step 12 contains multiple sub-steps:

• 12a: IAB setup IPSec tunnel and get a new inner IP address. **This is a 4-way handshake.**

• 12b: IAB-DU use new inner IP address to setup new SCTP association with CU. **This is a 4-way handshake.**

• 12c: IAB-DU initiate F1 procedure to inform CU for the new SCTP association and migrate F1-C to new SCTP association. **This is a 2-way handshake**.

• 12d: CU initiate F1 IAB UP Configuration Update, to get IAB’s new inner IP address for DL F1-U, etc. **This is a 2-way handshake**.

• 12e: CU-CP inform CU-UP for IAB’s new inner IP address for DL F1-U. The UL/DL F1-U can be resumed over the target path. **This is a 2-way handshake**.

Step 12 has 14-way handshake in total. By using MOBIKE, Step 12 can be reduced to 6-way handshake as below:

* 12a: IAB initiates MOBIKE procedure to update the outer IP address. The previous assigned inner IP address can be reused with the new outer IP address. **This is a 2-way handshake.**
* 12b: **this sub-step can be omitted**. Since the inner IP address is unchanged, the previously established SCTP association can be used over the new outer IP address.
* 12c: IAB-DU initiates a F1AP procedure to inform CU that inner IP address is reused, and F1-C/U can be resumed via current SCTP association and F1-U tunnel. **This is a 2-way handshake.**
* 12d: **this sub-step can be omitted**. Since the inner IP address is unchanged, no change to DL F1-U tunnel.
* 12e: CU-CP informs CU-UP to resume DL F1-U transmission. 2-way handshake. **This is a 2-way handshake.**

If needed, SA3 can be consulted on MOBIKE.

**Q4: Please share your view on using MOBIKE to reduce the service interruption**

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| **Company** | **Comment** |
| QC | We agree with the benefits of MOBIKE. RAN3 should support this solution. Also, MOBIKE messages can be sent in parallel with other traffic, which can further reduce the number of signaling handshakes for F1 migration. Since MobIKE is an IETF standard, which has been used elsewhere in 3GPP, we don’t believe SA3 approval is necessary. |
| Samsung | Sounds reasonable. We are not sure if there is any specification impact. To us, it is an implementation issue. In our specification, step 12 indicates the main purpose of such step. How to achieve it depends on the practical implementation.  |
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**Summary:**

**Potential proposal:**

## Inter-CU RLF

Contribution ([7][9][10]) discuss the inter-DU RLF.

* Contribution ([7][9]) propose to use RRC Re-establishment for the migrating IAB.
* Contribution ([7]) propose to study

1) Avoid signaling storm in F1 interface between IAB-DUs and new IAB-donor-CU.

2) Avoid long term service interruption for connected UEs.

Contribution ([7]) also propose to discuss how to handle the UE/descendant IAB, e.g.

1) How can descendent IAB-nodes and UEs be aware of the CU change?

2) Whether descendent IAB-nodes and UEs should re-establish to new IAB-donor-CU with the recovery IAB-node?

* Contribution ([9]) propose Xn procedure for transmitting the IAB-DU context and F1AP UE context, which is stored at the old IAB-donor-CU from the old IAB-donor-CU to the new IAB-donor-CU. Contribution ([9]) also propose to discuss which procedure (RRC Re-establishement or Handover) is the baseline procedure for updating AS security for descendant nodes of the IAB-node performing inter-CU recovery, and to consider the above options as candidate solutions to update AS security for descendant nodes.
* Contribution ([10]) propose Xn procedure for context store, where resource reservation is not done in advance.

**Q5-1: Please share your view on high level aspect of inter-CU RLF, e.g. whether use RRC Re-establishment procedure for the migrating IAB, whether the context for UE/descendant remains in Source Donor-CU or is moved to Target Donor-CU, etc.**

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| **Company** | **Comment** |
| QC | This is discussed in AI 13.2.1/CB 34. Both options, i.e., keep context in source CU vs. target CU, can and should be supported. |
| Samsung | Share the view as QC.  |
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**Q5-2: in case the context for UE/descendant IAB needs to be moved to target Donor-CU, whether need new Xn procedure, and how to handle the UE/descendant IAB, e.g. using HO procedure or RRC re-establishment procedure.**

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| **Company** | **Comment** |
| QC | Same as Q5-1 |
| Samsung  | This can be discussed after inter-donor migration is clear. We assume the procedure used for inter-donor migration can be simply applied for recovery case.  |
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**Summary:**

**Potential proposal:**

## Inter-Donor migration (Non RLF)

Contribution ([1][5]) discussed some proposals on inter-Donor migration (non-RLF). Moderator suggest that those enhancements for inter-Donor migration (non-RLF) can be discussed later, for example, once the basic inter-Donor migrating solution is agreed in AI 13.2.1.

## CHO and DAPS

All proposals related to CHO and DAPS will be handled in CB: # 35\_IAB\_CHO-DAPS.

## Other issues/enhancements

**Q8: Please list other issues/enhancements that should be considered? Please include assessment of expected benefit, impact on specification, implementation, other WGs.**

# Part II…[if needed]

If needed

# References

1. R3-210102, Reducing the Service Interruption for IAB (CATT)
2. R3-210217, Discussion on service interruption reduction for Rel-17 IAB (Samsung)
3. R3-210348, Interruption time reduction for Intra-donor IAB-node Migration (Qualcomm Incorporated)
4. R3-210390, Mitigation of Unnecessary Transmission (Intel Deutschland GmbH)
5. R3-210459, Discussion on reduction of service interruption (Fujitsu)
6. R3-210488, Discussion on Reduction of Service Interruption during Intra-Donor Topology Adaptation (Nokia, Nokia Shanghai Bell)
7. R3-210548, Inter-CU RLF recovery procedure (Huawei)
8. R3-210657, Service interruption reduction for intra-donor migration of IAB-node with descendant nodes (AT&T)
9. R3-210716, Discussion on reduction of service interruption in intra-donor migration and RLF recovery scenario (ZTE)
10. R3-210723, Reduction of Service Interruption in IAB Networks (Ericsson)