**3GPP TSG-RAN WG3 Meeting #114-eR3-215901**

**Online, November 1st - 11th 2021**

Agenda Item: 13.2.2

Source: Ericsson (moderator)

Title: Summary of Offline Discussion on the Reduction of Service Interruption

Document for: Approval

# Introduction

This is the SoD for the following comeback: **CB: # 1303\_IAB\_Red\_Serv\_Inter**

The deadline for providing replies to Phase 1 is **Thursday, November 4th at 23.59 UTC.**

Relevant papers:

1. R3-214689 Reply LS to RAN3 on reduction of service interruption during intra-donor IAB-node migration (RAN2)
2. R3-214823 Reduction of Service Interruption in IAB Migration (Ericsson)
3. R3-214874 Discussion on service interruption reduction for Rel-17 IAB (Samsung)
4. R3-214925 Further considerations on service interruption reduction (ZTE)
5. R3-214954 Reduction of service interruption during IAB migration (Qualcomm Incorporated)
6. R3-215014 Discussion on reduction of service interruption (CATT)
7. R3-215303 Service interruption reduction for IAB migration (Lenovo, Motorola Mobility)
8. R3-215345 (TP for BL CR for TS 38.401) Discussion on Reduction of Service Interruption (Nokia, Nokia Shanghai Bell)
9. R3-215612 Reduction of Service Interruption for IAB topology update (Huawei)

# For the Chairman’s Notes

**TBW**

# Discussion

**Disclaimer:** The Moderator prioritized some issues wrt some other. Some proposals have been left out because they are either too detailed at this stage or because they are dependent on other proposals.

## RRC Reconfiguration delivery via the source path in intra-donor migration

RAN3 is discussing two solutions for reduction of service interruption in intra-donor migration, where the transfer of RRC Reconfiguration for TNL migration of a descendent IAB node occurs over the source path. The two candidate solutions are:

* Solution 1, where the RRC Reconfiguration message for TNL migration of a descendent node IAB-MT is withheld by this descendant node’s parent IAB-DU, and it is delivered only when a condition is satisfied.
* Solution 2, where the RRC Reconfiguration message for TNL migration of the descendant-node IAB-MT is buffered by the descendent-node’s IAB-MT itself, and it is executed only when an indication is received from the parent IAB-DU.

After the RAN3#113-e meeting, the LS reply from RAN2 in [1] has arrived.

### Interaction with the CHO of the migrating node

It was previously agreed that Rel16 CHO is supported for the migrating IAB-MT in intra-donor migration. Paper [5] proposes the following:

* Solution 1 and CHO should not be supported together.
* Solution 2 and CHO should not be supported together.

The reason is that the opposite would require that RRC Reconfiguration messages for the descendants contain multiple sets of IP addresses, each set pertaining to one candidate target cell of the migrating IAB-MT.

**Potential proposal 1-1: Neither Solution 1 nor Solution 2 should be supported together with the CHO of the migrating node.**

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| **Company** | **Answer** |
| **Ericsson** | Agree |
| QCOM | Agree |
| Samsung | Agree |
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### Prerequisites at the descendant nodes

In Moderator’s understanding, at the RAN3#113-e meeting, the prerequisites pertaining to the migrating node in Solution 1 and Solution 2 were agreed. However, the agreement did not capture that the action taken by the migrating node in Solution 2 when the prerequisite is fulfilled is to transmit the L1/L2 signaling message to each of its child nodes. This can be corrected if Solution 2 is been selected.

The **prerequisites pertaining to the descendant nodes** were addressed in several papers, as follows:

* [5]: For **Sol1**, the IAB-node releases RRC Reconfiguration messages when it receives an RRC Reconfiguration message for itself that does not contain a change of Pcell.
* [9]: The RRC Reconfiguration transfer in **Sol1** and RRC Reconfiguration execution in **Sol2** can take place as soon as the routing table has been updated to have one or more entries for the target path (i.e., no RACH).
* [5]: For **Sol2**, when the IAB-node receives the L1/L2 signalling message from its parent node, it transmits the L1/L2 signalling message to each of its child nodes and executes the buffered RRC Reconfiguration message, if available.
* [4]: In **Sol2**, for descendant nodes, RRC Reconfiguration execution could be triggered as soon as the routing table at the descendant IAB node has been updated to have one or more entries for the target path, and the L1/L2 indication to trigger the execution of RRC Reconfiguration is received.

**Potential proposal 1-2:**

**For Sol1, a descendant node of the migrating node can release the RRC Reconfiguration messages towards each of its child nodes after:**

* **It has received an RRC Reconfiguration message for itself that does not contain a change of Pcell, AND**
* **Its routing table has been updated to have one or more entries for the target path.**

**Potential proposal 1-3:**

**For Sol2, a descendant node of the migrating node can transmit the L1/L2 signalling message to each of its child nodes after:**

* **It has received the L1/L2 signalling message from its parent node and executed the buffered RRC Reconfiguration message, AND**
* **After its routing table has been updated to have one or more entries for the target path.**

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| **Company** | **Answer** |
| **Ericsson** | **Agree to both** |
| **QCOM** | **Agree to both** |
| Samsung | For each solution, the first condition can be agreed.  However, the second bullet may need some discussions. The descendant nodes do not have any routing entry for the target path since the target path is transparent to it. Moreover, the descendant node cannot be aware which routing entry aims at transmitting data over target path. Thus, **we suggest to remove second condition for each proposal**. |
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### Migration failure of migrating IAB-MT in Solution 1

The following issue related to Solution 1 was raised:

* How to handle the buffered RRC Reconfiguration message, in case the migration of the migrating IAB-MT fails?
  + Paper [5] Argues that, in case of **failure of intra-migration and RLF recovery**:
    - At the **same Donor-DU**: the buffered RRC Reconfiguration can be reused and same conditions as in the case of success case can be reused.
    - At a **different Donor-DU**: both new and old RRC Reconfiguration should be delivered to the child, and since they will be received in a short time span, there is no issue with delivering the old RRC Reconfiguration.
  + On the other hand, paper [4] expresses doubts with respect to the statement from [5] and argues that parent IAB-DU does not know the RRC message content and hence cannot know when to release the buffered RRC Reconfiguration message.
  + Paper [9] analyses three possible ways of handling:
    - If **migrating IAB-node still sends** the buffered RRC Reconfiguration message, it will make the child IAB node to trigger TNL migration incorrectly.
    - Else if the **migrating IAB-node discards** the buffered RRC reconfiguration message, it will cause the PDCP SN gap in PDCP layer and the delivery of subsequent RRC messages may not be possible.
    - Else if the **migrating IAB-node sends some dummy message** to the child IAB node, it will cause the child IAB node to perform RRC Reestablishment.
  + Paper [9] argues that, in case Donor-CU sends a new RRC Reconfiguration message to the child IAB node after the buffered RRC Reconfiguration message, the new RRC Reconfiguration message will be delivered to the child IAB-MT’s RRC layer once its PDCP reorder timer expires, while the previous RRC Reconfiguration message is still buffered at parent node. There will be RRC configuration mismatch between child IAB-MT and Donor-CU due to the missing of the buffered RRC Reconfiguration message.

As noticed in paper [5], upon migration failure, the migrating node will attempt RLF recovery. In Moderator’s view, **if the RLF recovery fails**, the migrating node should not forward the buffered RRC Reconfiguration to its child nodes, because, in that case, the parent-child relations cease to exist, and every node is “on its own”. In other words, the **failure of RLF recovery (after failed migration) should not be considered.**

Regarding **successful RLF recovery of the migrating IAB-MT**, two cases can be considered:

* Successful RLF recovery at the **same target Donor-DU as the originally planned one**. case can be reused.
* Successful RLF recovery at a **different target Donor-DU than the originally planned one**.

**Q1-1: Do you agree that, for a migrating IAB-MT that successfully executed RLF recovery towards the same target Donor-DU as the originally planned one, the buffered RRC Reconfiguration can be reused, and the same conditions apply as in the case of migration success?**

**Q1-2: Do you agree that, for a migrating IAB-MT that successfully executed RLF recovery towards a target Donor-DU different than the originally planned one, both new and old RRC Reconfiguration should be delivered to the child?**

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| **Company** | **Answer** | **Motivation** |
| **Ericsson** | **Yes, to both.** | Regarding Q1-2, we think that the reception of two consecutive RRC Reconfiguration messages at a child node within a short time-window will not do any harm.  Regarding the concerns from [4], stating that the parent IAB-DU may not know whether the RRC message encapsulated within the UA F1AP message is RRC Reconfiguration, we think that this is easily solvable by introducing the flag in the F1AP message indicating to the parent IAB-DU to buffer the RRC message within. Please note that such a flag, pertaining only to RRC Reconfiguration messages, is needed anyway for Sol1, i.e., even for the general (i.e., non-failure) scenario. |
| **QCOM** | **Yes, to both** | We agree with Ericsson’s assessment |
| Samsung | Yes, to both | Share the same view as Ericsson. |
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In this meeting, we need to prioritize one of Sol1 and Sol2, and move forward with specification. Please indicate your preference.

**Q1-3: Which of Sol1 or Sol2 do you prefer? Are you fine with either solution?**

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| **Company** | **Sol 1 or Sol 2** | **Comment** |
| QCOM | Sol 1 | We believe that both solutions work, and that the specification effort for of them is manageable.  We prefer Sol1 since it does NOT require additional L2 signalling |
| Samsung | Sol 1 |  |
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## Avoidance of descendant node reconfiguration

The topic was addressed in papers [2, 3, 5, 6, 7].

### The solution for avoidance of descendant reconfiguration for inter-donor routing

Papers [2, 5, 6, 7] propose base the discussion on IP tunnelling between source and target donor-DUs, similar to what has been agreed for UL inter-donor rerouting.

**Potential proposal 2-1: For avoidance of descendant-node reconfiguration, RAN3 considers IP tunnelling via one or more IP tunnels established between source and target Donor-DUs.**

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| **Company** | **Answer** | **Motivation** |
| **Ericsson** | **Agree** | This is compatible with the inter-Donor-DU tunnelling that will be used for inter-donor UL rerouting. |
| **QCOM** | **Disagree** | We submitted [5] but we do not recall “proposing” such a solution.  While inter-donor-DU tunnel is the only viable solution among all the options discussed, **we do not agree** that this is the same as UL inter-donor rerouting.  While for UL, a tunnel can be statically configured, for DL, the tunnel needs to be dynamically configured and the exact cut-over time between direct transport and tunnelling is very critical, i.e., must be perfectly matched to the MT migration since there is no packet buffering, e.g., like in packet forwarding during HO.  Further, inter-donor-DU tunneling creates a very **suboptimal** transport path. This if fine for short term, e.g., as for local rerouting, but it is not a long-term transport solution. This means that the descendant-node reconfiguration is still necessary. To improve migration performance, Sol 1 and Sol 2 are completely adequate. |
| Samsung | See comments. | For IP tunneling, if only one inter-donor-DU tunnel is established, we are concerning the QoS guarantee. It is because that in legacy case, each DRB is configured with one or multiple tunnels so as to transmit different traffic via different tunnels. If multiple inter-donor-DU tunnels are established, the specification impact would be large.  Moreover, without reconfiguration to descendant nodes, such IP tunneling scheme should exist for the whole period where inter-topology F1 transport exists. This is different from UL inter-donor rerouting, which is only used for a temporary cases (e.g., in-flight packet during migration). It may cause additional processing burden and data transmission delay, which may not be able to reduce the service interruption time.  Compared to IP tunneling, allowing descendant node reconfiguration does not introduce too much specification impact. The service interruption time can be evaluated after the baseline inter-donor migration procedure is determined. Then, we can determine a suitable solution to resolve it.  If we really want to have a solution at this moment, as QC comments, we can use the IP tunnel for re-routing as a temporary solution to resolve the service interruption due to reconfiguration of descendant node.  Thus, we suggest:  **Avoidance reconfiguration of descendant node is postponed till the baseline inter-donor migration is clear when considering reconfiguring descendant node.**   * **A temporary IP tunnel (as suggested for inter-donor-DU re-routing) can be used to reduce the service interruption due to descendant node reconfiguration.** |
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### The scenarios to be considered

Paper [2] argues that avoidance of IP address reconfiguration applies to all the scenarios where inter-donor routing is used, i.e.:

* Partial migration.
* Topology redundancy.
* RLF recovery.

Paper [5] proposes to discuss the scenario for intra-donor migration first.

**Potential proposal 2-2: The avoidance of descendant reconfiguration is considered for the following scenarios:**

1. **Partial inter-donor migration.**
2. **Topology redundancy.**
3. **Inter-donor RLF recovery.**
4. **Intra-donor migration.**

**NOTE:** The proposal is **not about prioritization**, but rather about general relevance.

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| **Company** | **Answer** | **Motivation** |
| **Ericsson** | **Agree** | **A, B and C:** all these scenarios use inter-donor routing, where descendant nodes of the boundary node remain anchored at CU1 and they should be able to keep using the IP addresses from CU1 domain. Changing their IP addresses introduces additional service interruption, since each descendant IAB node needs to receive the new IP addresses via RRC, then set up SCTP association(s) using the new IP address(es), in order to be able to deliver the RRC Reconfiguration to child IAB nodes. Moreover, the addresses would need to be updated for F1-U tunnels as well.  **D:** this case also includes IP address change, so the same benefits apply for this case as well. |
| **Qualcomm** | **Disagree** | Again, inter-donor-DU-routing creates a suboptimal transport path and should only be used as temporary relief. Descendent-node reconfiguration is therefore necessary. Sol1 and/or Sol2 are sufficient for temporary relief. |
| Samsung | Agree A/C/D if avoidance of descendant node reconfiguration is agreed in RAN3. | If avoiding reconfiguration to descendant node is agreed in RAN3, the above scenarios can be considered. However, we are not sure if scenario B has any service interruption since the paths under CU1 are always available. |
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Paper [5] proposes that the avoidance of descendant node reconfiguration should be first discussed for intra-donor migration, until the solution for descendent-node migration in inter-donor partial migration has been defined.

In Moderator’s understanding, the solution for avoidance of descendant node reconfiguration in both intra- and inter-donor case roughly consists of:

1. **Setting up the inter-Donor-DU tunnels:**
   * The mechanism for setting up tunnels for inter-donor UL rerouting (AI 13.3.2) can be fully reused.
2. **Configuring the Donor-DUs** how to recognize and handle the packets to be tunnelled:
   * For **UL** traffic, the solution for inter-donor UL rerouting produced in AI 13.3.2 can be reused in full or with minor enhancements, depending on whether BAP or IP packets are to be tunnelled.
   * For **DL**, the signalling for configuring the Donor-Dus that is to be specified in AI 13.3.2 can be reused, with minor DL-specific enhancements.
3. **Setting up the target path** for inter-donor routing:
   * Target path setup is discussed in AI 13.2.1.1 and AI 13.2.3 and is needed for all inter-donor routing scenarios, not just for the sake of the present discussion. The mechanism for configuring the new ancestors of the boundary node can be reused in full. As mentioned in point 2), the Donor-DU reconfiguration needs separate handling.

**Potential proposal 2-3:**

**The solution for avoidance of descendant-node reconfiguration reuses, as baseline, the following mechanisms defined for UL inter-donor rerouting:**

* **Setting up inter-Donor-DU tunnels.**
* **Configuring the source and target Donor-Dus.**

**The necessary enhancements are FFS.**

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| **Company** | **Answer** | **Motivation** |
| **Ericsson** | **Agree** | The bulk of the work will be done in 13.3.2, and the present use case can be served with minor enhancements. |
| **QCOM** | **Disagree** | **We disapprove of avoidance of descendent-node migration since it is not necessary. We should stop discussing this matter.**  **In this meeting, we wanted to down-select between Sol 1 and Sol 2. This hasn’t been addressed in this email discussion.** |
| Samsung | Disagree |  |
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## Inter-donor routing setup

Paper [3] argues that, in partial inter-donor migration, the steps related to context transfer between the source and target CU, and the target path configuration, are the biggest contributors to service interruption.

Two general methods, entailing five different options for reduction of service interruption during inter-donor topology adaptation were discussed.

* **Method 1:** **Proper timing** for executing inter-donor context transfer and target path setup:
* **Option 1:** Triggered before sending Handover Request message.
* **Option 2:** Triggered after receiving Handover Request ACK message.
* **Option 3:** Triggered by the non-F1-termination donor, i.e., non-F1-termination donor sends indication to F1-termination donor.
* **Option 4:** Triggered by the boundary IAB node, i.e., triggered by receiving the first message via new IP address of boundary node.
* **Method 2:** Introducing **default BH configuration for UP UL** traffic:
* **Option 5:** The RRC Reconfiguration message can include default UP mapping information, i.e., default BAP routing ID, default BH RLC CH, for all UL F1-U traffic.

**Q3-1: Please state your view on the above Options.**

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| **Company** | **Answer** |
| **Ericsson** | **Up to implementation.**  RAN3 should define the procedure for inter-donor routing setup (i.e., for transferring he contexts between donors) for all the scenarios of interest: partial migration, RLF recovery, topology redundancy. When the network triggers the execution of the procedure should be **up to implementation**.  For example, as noticed in [3], Option 1 can be used for planned load balancing, since in that case the source and target Donors may have enough time to prepare the target path before the migration.  For the case of abrupt change of conditions under the source donor, we think that the concern related to Options 1 and 2 expressed in [3] (i.e., unnecessary setup of target path in case boundary MT migration fails) can be resolved if the source CU transfers the context necessary for target path setup in parallel with the HANDOVER REQUEST for the boundary MT and the target CU builds the target path and responds to the source CU after the boundary MT has successfully connected to target CU.  In any case, when deciding whether to accept the handover or the RLF recovery of the boundary MT, the target CU should be able to take an educated decision, which is only possible if it knows to how much backhaul resources it needs to allocate for the target path for partial migration/RLF recovery. This is not ensured by Options 3-5. |
| **QCOM** | **We disapprove of avoidance of descendent-node migration since it is not necessary. We should stop discussing this matter.**  **In this meeting, we wanted to down-select between Sol 1 and Sol 2. This hasn’t been addressed in this email discussion.** |
| Samsung | This issue cannot be resolved by simply saying “up to implementation”.   * Case of load balancing   We need to identify whether the unnecessary setup of target path in case boundary MT migration fails is acceptable. This is different from the normal handover, such resource pre-reservation will consume a large amount of resource at the target path due to all the traffic under boundary node and descendant node(s). Thus, we need answer the following question:  **Can we accept the unnecessary setup of target path in case boundary MT migration fails?**  Assuming the answer is yes, we can discuss the case of load balancing, and the option 1&option 2 is applicable, i.e.,  Our 1st view: Option 1&2 can be applied if we can accept the unnecessary setup of target path in case of boundary MT migration fails for case of load balancing.   * Case of abrupt change of conditions   In this case, target path cannot be prepared in advance. E/// mentioned that “the source CU transfers the context necessary for target path setup in parallel with the HANDOVER REQUEST for the boundary MT and the target CU builds the target path and responds to the source CU after the boundary MT has successfully connected to target CU”. We have the following concern:   * **The current WA may not allow to send context in parallel with the HO REQ message.**   Our WA assumes that new IP addresses of boundary node is not provided to the CU1 via HO REQ ACK message. If this WA is finally agreed, it means that the CU2 will use the new IP address of boundary node only to configure the DL mapping at CU2’s donor DU, which is used to transmit IKE/SCTP related packets. To ensure the DL mapping based on IP address only, the CU2 cannot configure any other DL mappings based on IP + DSCP/Flow label since the IP packets from CU1, e.g., SCTP INIT ACK, may have a DSCP/Flow label conflict with DL mappings. In other words, the DL mapping for other traffic should be configured after CU1 knows the new IP address of boundary node (i.e., after receiving F1AP gNB-DU configuration update message).  **The current WA can only allow to start the context (QoS Info.) transfer after informing new IP addresses of boundary node.**  To resolve this concern, we can allow the CU1 knows new IP address and DSCP/FL for IKE/SCTP traffic via the HO REQ ACK message. If this is agreeable, context transfer in parallel with HO REQ message is possible.  Our 2nd view: for case of abrupt change of conditions, if HO REQ ACK message is used to inform new IP address and DSCP/FL for F1-C related traffic (e.g., IKE/SCTP traffic), the context transfer can be implemented in parallel with HO REQ message, and Option 3&4 is not needed.   * **Target path preparation is time-consuming compared to RACH procedure of boundary IAB-MT**   Even we have parallel message transmission, the target path preparation is still time-consuming. It is realized by configuring each IAB node in the target path, which is not implemented in parallel. Moreover, each IAB node configuration requires at least 6 signalings (4 for F1AP, and 2 for RRC). Thus, it is hard to assume that the target path preparation can be finished before RACH of boundary IAB-MT.  **We cannot simply assume that the target path preparation can be finished before RACH of the boundary IAB-MT**  The abrupt change of conditions requires to implement the boundary IAB-MT migration very quickly, while target path preparation is time-consuming. Thus, **the normal assumption is that the target path preparation is finished after RACH of the boundary IAB-MT**  With this assumption, Option 5 can be a choice to resolve the interruption during the time gap between success RACH of boundary IAB-MT and target path preparation.  Our 3rd view: Option 5 can be a choice to resolve the interruption during the time gap between success RACH of boundary IAB-MT and target path preparation.  In addition, E/// mentions that CU1 needs to know whether the CU2 can admit the traffic of boundary/descendant node. This can be achieved by responding to CU1 after finishing target path preparation. However, another way is that the CU1 can provide some rough load information of boundary/descendant nodes in HO REQ message to allow CU2 make a rough admission control. |
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## Support for MOBIKE in intra-donor migration

Paper [8] Argues that the donor CU is unaware of whether the MOBIKE is applied to intra-donor migration, and further, if it was successfully applied. It is hence proposed to use the GNB-DU CONFIGURATION UPDATE F1AP message to explicitly indicate such an outcome to the donor CU.

Moreover, a TP for IAB BL CR for TS 38.401 is submitted.

**Potential proposal 4-1: After the MOBIKE is successfully performed during intra-donor migration, the IAB-DU sends an F1AP GNB-DU CONFIGURATION UPDATE message to inform the IAB-donor-CU that the existing inner IP address can be reused i.e. that the MOBIKE is successfully performed.**

**Note**: the Proponent is invited to explain the difference between Proposals 3 and 4, which are, in the first version of this SoD, treated as identical.

**Potential proposal 4-2: The following update to the Intra-CU Topology Adaptation procedure in clause 8.2.3.1 of the TS 38.401 is agreed:**

In case IPsec tunnel mode is used for TNL protection, the IAB-node may use MOBIKE to migrate the IPsec tunnel to the new outer IP addresses. After the completion of the MOBIKE procedure, the IAB-DU initiates a F1AP gNB-DU Configuration Update procedure to inform the IAB-donor-CU that the existing inner IP address(es) (e.g. for SCTP association and the DL FTEID can be reused).

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| **Company** | **Agree/disagree? Please motivate if you disagree** |
| **Ericsson** | Agree to both. |
| **QCOM** | Agree to both |
| Samsung | We are wondering if this new indication can be implicitly deduced via MOBIKE procedure. |
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## Avoidance of unnecessary UL transmissions

Paper [9] argues that, given that UL inter-donor routing helps avoid unnecessary UL transmissions, no further enhancements are necessary.

**Potential proposal 5: No further enhancements for the avoidance of unnecessary UL transmissions, other than local UL rerouting, are specified in Rel-17.**

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| **Company** | **Agree/disagree? Please motivate if you disagree** |
| **Ericsson** | Agree |
| **QCOM** | **Agree** |
| Samsung | Agree |
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