3GPP TSG-RAN WG2 Meeting #114 bis electronic R2-2xxxxxx
Online, April 12 – April 20, 2021

Agenda Item: 8.4.3

Source: Qualcomm Incorporated

**Title:** **Report [Post113-e][058][IAB17] Inter-donor topology adaptation**

Document for: Discussion

# Introduction

This document handles email discussion:

* [Post113-e][058][IAB17] Inter-donor topology adaptation (Qualcomm)

 Scope: First round of discussion to understand impacts of inter-donor topology adaptation, based on RAN3 progress, and related required decisions in RAN2. Include e.g. BAP/IP routing and CP/UP split. Clarify the options on the table and their consequences. Pave the way for prioritization and selection decisions (to the extent possible).

 Intended outcome: Report

 Deadline: Long

We will try to cover two phases in this discussion.

**Phase 1**: Converge on the implications from RAN3 progress on RAN2.

The deadline of Phase 1 is Thursday, March 18, 11:00 UTC.

**Phase 2**: Derive proposals for online discussing during #114e.

The deadline of Phase 2 is Friday, March 26 11:00 UTC.

The discussion is based on RAN3 progress on inter-donor topology adaptation and CP-UP split. I have copied the RAN3 agreements [1] here:

<https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113-e/Inbox/Drafts/eIAB>

The discussion includes two LS send by RAN3 to RAN2:

* [R2-2100040](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113-e/Docs/R2-2100040.zip) LS on CP-UP separation of Rel-17 IAB (RAN3#110e)
* [R3-211331](https://www.3gpp.org/ftp/tsg_ran/WG3_Iu/TSGR3_111-e/Inbox/R3-211331.zip) LS on inter-donor topology redundancy (RAN3#111e)

The discussion includes additional RAN3 agreements from [1].

The discussion further includes the following contributions on CP-UP separation submitted to R2#113e:

* R2-2100612 On CP/UP split for topology adaptation enhancement (Nokia)
* R2-2101282 Discussion on CP/UP separation (ZTE, Sanechips)
* R2-2101905 Issues on UL RLF notification and CP-UP separation (Samsung)

# Discussion

## 2.1 CP-UP Separation

LS R2-2100040 states the following:

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| 1. **Overall Description:**

RAN3 discussed the CP-UP separation and identified the benefit of allowing the F1-C over NR access link in FR1, e.g., improve the reliability and reduce the latency of F1-C traffic. Moreover, the following agreements were achieved:* **In Rel-17 eIAB, the following two scenarios are supported for CP-UP separation, as shown in the following figure:**
* **Scenario 1: F1-C uses NR access link via M-NG-RAN node (non-donor node) + F1-U uses backhaul link via S-NG-RAN node (donor node)**
* **Scenario 2: F1-U uses backhaul link via M-NG-RAN node (donor node) + F1-C uses NR access link via S-NG-RAN node (non-donor node)**

Meanwhile, RAN3 analyzed the potential impacts to the specifications, which are similar to the design for EN-DC case in Rel-16. The following potential RAN2 impacts are identified during the discussion:1. NR RRC for F1-C transfer path configuration

**ACTION:** RAN3 respectfully asks RAN2 to take the above into account and to decide specification impact for CP-UP separation. |

RAN3#111e further agreed:

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| [R3-211327](file:///C%3A%5CUsers%5Cghampel%5CAppData%5CRoaming%5CMicrosoft%5Cchairman%5CInbox%5CR3-211327.zip) **Endorsed unseen as BL**[R3-211329](file:///C%3A%5CUsers%5Cghampel%5CAppData%5CRoaming%5CMicrosoft%5Cchairman%5CInbox%5CR3-211329.zip) **Endorsed unseen as BL****To support CP-UP separation, the node terminating F1 interface for the IAB-node determines the transfer path of F1-C traffic** |

R3-211327 and R3211329 include CRs to TS 38.423 and TS38.420, which add the F1-C transfer procedure to Xn.

### 2.1.1 Scenario 1: SN has donor functionality

R2-2101282 and R2-2101905 discuss which SRB to be used for scenario 1. R2-2101282 proposes that SRB2 is used. R2-2101905 considers both SRB1 and SRB2 as options. Note that Rel-16 IAB only uses SRB2 for transport of F1-C over LTE.

**Q1a: Should SRB1 and/or SRB2 be used for F1-C transport in scenario 1?**

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| Company | SRB used | Comment |
| LG | SRB2 | Same argument as discussed in Rel-16 F1-C over LTE is valid for scenario 1. |
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R2-2100612 and R2-2101282 propose that NR *DLInformationTransfer* and *ULInformationTransfer* messages are enhanced to transfer F1-C related information in scenario 1. This represents the same solution as currently used for F1-C transport over LTE.

**Q1b: Do you agree that NR *DLInformationTransfer* and *ULInformationTransfer* are enhanced to transfer F1-C related information for scenario 1?**

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| Company | Yes/No | Comment |
| LG | Yes | A new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information.  |
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**Q1c: Are there other aspects (e.g. RRC changes) to be considered for scenario 1?**

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| Company | Comment |
| Qualcomm | 1. The F1-C transfer path to be selected (SN, MN, both) needs to be added to cell group config.2. UE capability f1c-OverNR-r17 needs to be added to NR RRC. |
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### 2.1.2 Scenario 2: MN has donor functionality

R2-2101282 and R2-2101905 discuss SRB3 and split SRB2 as potential candidates to carry F1-C traffic.

**Option 1: Using SRB3**

Support for SRB3 is not mandatory. Establishment of SRB3 is decided by the SN. However, according to RAN3’s agreement, it is the MN that decides on the routing path of F1-C. Therefore, the MN would have to be able to ask SN to establish SRB3 for this purpose.

R2-2101282 further proposes to enhance *ULInformationTransferMRDC* message and *DLInformationTransferMRDC* to enable transfer of F1-C via SRB3.

**Option 2: Using split SRB**

Support for split SRB is not mandatory either. The MN configures the split SRB after asking the SN to allocate resources. This would comply with RAN3’s agreement that it is up to the MN to decide the F1-C routing path in scenario 2.

R2-2101282 proposes to enhance *ULInformationTransfer* message and *DLInformationTransfer* to enable transfer of F1-C via split SRB.

**Q2a: Which of SRB3 and/or split SRB should be used for the transport of F1-C in scenario 2?**

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| Company | SRB used | Comment |
| LG | SRB3 preferred | Considering that path configuration can indicate explicitly SN, MN or both, SRB3 would be easier approach as in Rel-16 F1-C over LTE. On the other hand, in split SRB, transmission path is determined in PDCP layer with *primaryPath* and DataSplitThreshold. So if split SRB is used with explicit path configuration, some additional configuration/handling may be needed. |
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**Q2b: In case SRB3 is used, how would the MN initiate establishment of SRB3?**

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| Company | Comment |
| LG | Given that, SRB3 is established by the SN in legacy NR, SRB3 on the SN needs to be established first before starting to use CP-UP separation. |
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**Q2c: Do you agree that NR *DLInformationTransfer* and *ULInformationTransfer* need to be enhanced to transfer F1-C related information in case of split SRB?**

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| Company | SRB used | Comment |
| LG | Yes | Anyway, a new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information. |
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**Q2d: Do you agree that NR *DLInformationTransferMRDC* and *ULInformationTransferMRDC* need to be enhanced to transfer F1-C related information in case of SRB3?**

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| Company | SRB used | Comment |
| LG | Yes | Anyway, a new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information. |
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**Q2e: In case neither SRB3 nor split SRB are available, how would scenario 2 be supported?**

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| Company | Comment |
| LG | In case neither SRB3 nor split SRB are available, scenario 2 for CP-UP separation should not be supported. |
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**Q2f: Are there other aspects (e.g. RRC changes) to be considered for scenario 2?**

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| Company | Comment |
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## 2.2 Inter-donor redundancy

LS [R3-211331](https://www.3gpp.org/ftp/tsg_ran/WG3_Iu/TSGR3_111-e/Inbox/R3-211331.zip) states the following:

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| 1. **Overall Description:**

RAN3 has agreed the following two scenarios for the inter-donor topology redundancy: * **Scenario 1: the IAB is multi-connected with 2 Donors.**
* **Scenario 2: the IAB’s parent/ancestor node is multi-connected with 2 Donors.**

(*Note: in previous LS to RAN2, i.e., R2-2100041, the support of these two scenarios is the working assumption in RAN3*). In these two scenarios, RAN3 uses the following terminologies:* Boundary IAB node: the node accesses two different parents node connected to two different donor CUs, respectively, e.g., IAB 3 in above figures;
* Descendant IAB node: the node(s) accessing to network via boundary IAB node, and each node is single-connected to its parent node, e.g., IAB4 in scenario 2
* F1-termination node: the donor CU terminating F1 interface of the boundary IAB node and descendant node(s)
* Non-F1-termination node: the CU with donor functionalities, which does not terminate F1 interface of the boundary IAB node and descendant node(s)

To support the above two scenarios, RAN3 has made the following agreements:About F1 termination points:* + As a starting point, the F1 interface of the boundary IAB node and descendant IAB node(s) terminate to the same donor
	+ The F1-terminating donor initiates the traffic offload to the other donor’s topology

About the granularity of load balancing:* + For an MT with simultaneous connectivity to two IAB-donors, per-F1-U tunnel load balancing should be supported
	+ In inter-donor topology redundancy, the granularities of the load balancing is per TNL association for F1-C traffic

About IP address assignment:* + Both F1-termination node and non-F1-termination node can assign IP address(es) to the boundary IAB node.

**About BAP routing and bearer mapping between two topologies:*** + **To support the bearer mapping across two topologies at the boundary IAB node, the non-F1-termination donor CU needs to provide the ingress BH RLC CH ID(s) for DL traffic and egress BH RLC CH ID(s) for UL traffic to the F1-termination donor CU.**
	+ **The boundary IAB node belongs to two topologies of two donor CUs.**
	+ **RAN3 has considered the following options for the BAP routing across two topologies, i.e.,**
* **Option 1: OAM based solution**
* **Option 3: routing via a new unique identity (e.g., extended BAP address with CU component, separate set of (e)LCIDs)**
* **Option 4: BAP header rewriting based on BAP routing ID at, e.g., the boundary node**
* **Option 5: BAP header rewriting based on IP header at, e.g., the boundary node (seems to also impact RAN2)**

**ACTION:** RAN3 respectfully asks RAN2 to take the above into account and be involved in the design of inter-donor topology redundancy and provide feedback if any.  |

Other agreements on this topic by RAN3#111e

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| **WA: NRDC is supported as a baseline procedure for the IAB-MT’s simultaneous connectivity to two IAB-donors; DAPS-like solution is not precluded****In Rel-17, RAN3 agrees to support the following scenarios for inter-donor topology redundancy with the principle that an IAB-DU only has F1 interface with one Donor-CU:****- Scenario 1: the IAB node is multi-connected with 2 Donors.****- Scenario 2: the IAB node’s parent/ancestor node is multi-connected with 2 Donors.****The BH RLC channel management for each BH link is controlled by the CU who controls the topology containing the BH link.** |

This following discussion focusses on the agreements in the LS listed under “**About BAP routing and bearer mapping between two topologies”.**

**The discussion only focusses on transport. The question on “who configures what” will be discussed later.**

For ease of discussion, we assume that the boundary node connects via NRDC, which currently is a baseline WA in RAN3. This does not preclude using potentially other procedures, e.g., based on DAPS.

The goal of this discussion is to understand the technical solutions envisioned by RAN3 for option 1, 3, 4, and 5 of inter-topology routing and bearer mapping.

### 2.2.1 Problem of inter-topology BAP routing

Figure 1a shows an example of two IAB topologies referred to as topology 1 (blue, controlled by CU1) and topology 2 (green, controlled by CU2), which are interconnected by the boundary IAB-node-3. The boundary node was initially part of the blue topology 1 via an MCG link and added an SCG link to topology 2 at a later point in time.

IAB-DU3 (on the boundary node) and the descendent IAB-node-4 remain with topology 1, i.e., they have their F1 connectivity with CU1. IAB-DU3’s and IAB-DU4’s F1 traffic can be routed on the IP layer via IAB-donor-DU1 (i.e. only topology 1) or via IAB-donor-DU2 (i.e. across topologies 1 and 2).



**Figure 1a – Example scenario with redundant IP routing via two interconnected topologies**

**Problem:**

We assume that the IAB-nodes and IAB-donor-DUs received BAP addresses from their respective IAB-donor-CUs before IAB-node-3 established the SCG link to topology 2.

Since assignment of BAP addresses, BAP path IDs and BH RLC CH IDs occurs independently in each topology, the same values may be reused in each topology.

When packets are routed across both topologies, i.e., between the boundary IAB-node or its descendent nodes and donor-DU-2, collisions among BAP addresses, BAP path IDs and BH RLC CH IDs may occur.

In Figure 1 (left), both IAB-donor-DUs have the same BAP address. Therefore, the BAP address on UL BAP PDUs cannot be used to differentiate between these two destinations.

In Figure 1 (center), IAB-nodes 4 and 5 have the same BAP address. Therefore, the BAP address on DL BAP PDUs cannot be used to differentiate between these two destinations.

In Figure 1 (right), IAB-nodes 2 and 3 have the same BAP address. Therefore, the BAP address on DL PDUs cannot be used by IAB-node-2 to decide if the packet has to be forwarded to upper layers or to the next hop.

The following options 1, 3a, 3b, 4 and 5 agreed by RAN3 aim to address these issues.



**Figure 1b - Conflicts on PDU forwarding for inter-topology BAP routing**

### 2.2.2 Option 1: OAM-based solution

In this option, OAM-based configuration ensures that conflicts due to collisions in the BAP and BH RLC CH name spaces are avoided. Such OAM-based solution can always be supported. How they work is out of scope.

### 2.2.3 Option 3a: Routing via unique identity – Extended BAP address

In this option, BAP routing uses identifiers, which are unique across both topologies. This is accomplished by extending the BAP address with a CU-related identifier.

Figure 2 shows how this option is applied to the above example. In this example, the BAP address is extended with a CU-related ID referred to as CU1id for CU1 and CU2id for CU2.

Note that in this option, the traffic to different destination topologies can share the same BH RLC channel.



**Figure 2: Option 3a - Extending BAP address with CU-specific ID to create unique routes across both topologies**

What needs to be done:

* All instances of the BAP address, i.e., in the BAP header, the default routing configuration, the routing configuration, UL/DL mapping configurations, etc. need to include an CU-related identifier.
* The CU-related identifier needs to be globally unique.

**Q3a: Please provide feedback, comments, e.g., on open issues or aspects missing, if any, on option 3a.**

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| --- | --- |
| **Company** | **Comment** |
| LG | BAP address collision should be very rare due to following reasons:Normally, the donor CU1 and donor CU2 would be controlled by one operator. In addition, considering that the current length of BAP address is 10bits and this can cover 1024 IAB nodes, we think that proper network configuration can avoid this BAP address collision. So we doubt whether BAP address collision is a valid problem.If BAP address needs to be extended, RAN2 can just give more bits to the BAP address, but it doesn’t need to specify a CU-related identifier in BAP address format which is globally unique. |
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### 2.2.4 Option 3b: Routing via unique identity – Separate LCID

In this option, a separate set of BH RLC channels is configured for PDUs that remain in the same topology vs. PDUs that cross into another topology. The IAB-node/IAB-donor-DU further receives a separate set of routing-, bearer-mapping- and UL/DL-mapping configurations for each of these two types of PDUs. The eLCID of the ingress BH RLC channel indicates the routing- and bearer-mapping tables to be used for a PDU. For DL and UL mapping, the tables are selected based on upper layer information (e.g. destination IP header information for DL mapping and F1-related information for UL mapping).

Figure 2 shows how this option is applied to the above example. In this example, IAB-nodes 3 and 4 hold two separate UL routing tables indicated with Tcu1 and Tcu2 for destinations residing in the blue and the green topology, respectively. IAB-node 2 hold separate DL routing and bearer mapping tables for destinations in blue and green topology, respectively. IAB-donor-DU2 hold separate DL mapping and routing tables with respect to both topologies.

Note that in this option, the traffic to different destination topologies cannot share the same BH RLC channel.



**Figure 3: Option 3b - Topology differentiation based on LCID and topology-specific routing-/UL-/DL- tables**

What needs to be done:

* A CU Id is added to each routing-, bearer-mapping-, UL/DL-mapping-, BAP-address- and BH-RLC-CH configuration. This allows the nodes to create topology-specific tables and BH RLC Channels. It allows the IAB-node to associate its BAP address with a specific topology.
* The DU stores the mapping between (e)LCID for each BH RLC channel and the CU Id to select routing and bearer mapping tables based on ingress RLC channel.
* DL PDUs are only matched to the local BAP address if they are destined for the same topology (i.e. are received from BH RLC CH with same CU ID as the locally configured BAP address). This needs to be captured in the BAP specification.

**Q3b: Please provide feedback, comments, e.g., on open issues or aspects missing, if any, on option 3b.**

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| **Company** | **Comment** |
| LG | BAP address collision should be very rare due to following reasons:Normally, the donor CU1 and donor CU2 would be controlled by one operator. In addition, considering that the current length of BAP address is 10bits and this can cover 1024 IAB nodes, we think that proper network configuration can avoid this BAP address collision. So we doubt whether BAP address collision is a valid problem. |
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### 2.2.5 Option 4: BAP header rewriting based on BAP-routing-ID

In option 4, routing is local to each topology, i.e., BAP address, BAP path ID and BH RLC CH IDs have only local scope and can be reused in each topology. To enable inter-topology routing, the BAP routing ID carried on the BAP header is rewritten by the boundary node. For that purpose, the boundary node holds a mapping table, which maps the BAP routing ID of the PDU arriving from one topology to the BAP routing ID the PDU has to carry in the other topology.

Figure 4 shows how this option is applied to the above example. In this example, the boundary node has a mapping from UL BAP routing ID = (A3, Px) to UL BAP routing ID = (A1, Py) and DL BAP routing ID (A5, Px) to DL BAP routing ID (A4, Py).

Note that in this option, the traffic to different destination topologies can share the same BH RLC channel.



**Figure 4: Option 4 – BAP header rewriting based on BAP routing ID**

What needs to be done (example):

* The boundary node needs to be configurable with a separate BAP address for the second topology.
* The boundary node needs to be configurable with a BAP-header-rewriting table, which maps ingress BAP-routing-ID to egress BAP-routing-ID.
* BAP header rewriting needs to be captured in the BAP specification.
* The boundary node needs to be able to differentiate between PDUs, whose header is to be rewritten, and PDUs that are forwarded to next hop in the same topology or sent to upper layers. It is possible to overload the current BAP routing ID space for this purpose. The boundary IAB-node could, for instance, obtain separate BAP addresses in each topology that are only used for PDUs, whose header is to be rewritten.

**Q4: Please provide feedback, comments, e.g., on open issues or aspects missing, if any, on option 4.**

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| **Company** | **Comment** |
| LG | BAP address collision should be very rare due to following reasons:Normally, the donor CU1 and donor CU2 would be controlled by one operator. In addition, considering that the current length of BAP address is 10bits and this can cover 1024 IAB nodes, we think that proper network configuration can avoid this BAP address collision. So we doubt whether BAP address collision is a valid problem. |
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### 2.2.6 Option 5: BAP header rewriting based on IP header

In option 5, routing is also local to each topology, i.e., BAP address, BAP path ID and BH RLC CH IDs have only local scope and can be reused in each topology. To enable inter-topology routing, the BAP routing ID carried on the BAP header is also rewritten by the boundary node. The boundary node also has to carry a separate BAP address in each topology.

Opposed to option 4, the boundary node derives the new BAP routing ID based on IP header information. For both, UL and DL directions, this IP-to-L2 mapping is equivalent to the DL mapping presently conducted at the IAB-donor-DU.

Figure 5 shows how this option is applied to the above example. In this example, the boundary node has a mapping from IP header fields to BAP routing ID = (A1, Py) in UL direction and from IP header fields to BAP routing ID (A4, Py) in DL direction. The IP header fields are not shown here.

Note that in this option, the traffic to different destination topologies can share the same BH RLC channel.



**Figure 5: Option 5 – BAP header rewriting based on IP header**

What needs to be done:

* The boundary node needs to be configurable with a separate BAP address for the second topology.
* The boundary node needs to be configurable with an UL and DL mapping table equivalent to that presently configured on the IAB-donor-DU. The UL mapping table needs to include source IP addresses as selection criteria. Further, discussion is necessary.
* The UL mapping on the access IAB-node needs to be configurable to also set the IPv6 Flow Label and DSCP value on the IP header (as presently supported on the CU-UP).
* This option will have to involve RAN3.

**Q5: Please provide feedback, comments, e.g., on open issues or aspects missing, if any, on option 5.**

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| **Company** | **Comment** |
| LG | BAP address collision should be very rare due to following reasons:Normally, the donor CU1 and donor CU2 would be controlled by one operator. In addition, considering that the current length of BAP address is 10bits and this can cover 1024 IAB nodes, we think that proper network configuration can avoid this BAP address collision. So we doubt whether BAP address collision is a valid problem. |
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### 2.2.7 Ranking of options 1, 3a, 3b, 4 and 5

While more discussion will be necessary, the following question gives companies the opportunity to provide a first feedback on their views of these options. We allow each company to rank the above options 3a, 3b, 4 and 5 based on preference.

**Q6: Please rank the options 1, 3a, 3b, 4 and 5 based on your preference. You can leave options unmarked in case you do not support them.**

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| **Company** | **Rank (1, 2, 3 or 4)****Option 1**OAM-based solution | **Rank (1, 2, 3 or 4)****Option 3a**Routing via unique identity: BAP address extended with CU ID | **Rank (1, 2, 3 or 4)****Option 3b**Routing via unique identity: BAP address + separate LCID | **Rank (1, 2, 3 or 4)****Option 4**BAP header rewriting based on BAP routing ID | **Rank (1, 2, 3 or 4)****Option 5**BAP header rewriting based on IP header |
| LG | 1We think that option 1 should be also on the table and the option 1 is the simplest solution. |  |  |  |  |
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### 2.2.8 Bearer mapping at boundary node

The RAN3 agreement:

* + **To support the bearer mapping across two topologies at the boundary IAB node, the non-F1-termination donor CU needs to provide the ingress BH RLC CH ID(s) for DL traffic and egress BH RLC CH ID(s) for UL traffic to the F1-termination donor CU.**

has the implication that ingress-to-egress BH RLC channels are mapped 1:1 at the boundary node. This is the same as applied in Rel-16 IAB at every intermediate IAB-node. One example for three BH RLC channels is shown in Figure 6.



**Figure 6: Example for 1:1 ingress-to-egress RLC channel mapping at boundary IAB-node**

**Q6: Please provide feedback, comments, e.g., on bearer mapping across the boundary node, if any.**

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| **Company** | **Comment** |
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# Phase 2

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# Conclusion

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# References

1. Chairman report, 3GPP RAN TSG WG3 Meeting #111e, Electronic Meeting, Jan 25 - Feb 5, 2021