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?**

|  |  |  |
| --- | --- | --- |
| Company | SRB used | Comment |
| LG | SRB2 | Same argument as discussed in Rel-16 F1-C over LTE is valid for scenario 1. |
| Kyocera | SRB2 | We don’t have strong opinion, but we’re wondering if F1-C related information really requires the high priority transfer. So, we assume if Rel-16 mechanism can be reused.  |
| Fujitsu | SRB2 | Reuse R16 F1-C over LTE solution for NR-DC. |
| Ericsson | SRB2 | We do not see the reason to diverge from F1-C over LTE, in which SRB2 is used. |
| Samsung | SRB2, but… | We are ok with Rel-16 solution for F1-C over LTE being used as baseline. However, we need to note an issue with that solution: current RRC specification focuses on the the message being used for F1-C traffic transfer (DLInformationTransfer and ULInformationTransfer), which can be transmitted by either SRB1 or SRB2. Given the fact that there is no clarification on how to handle F1-C when UL/DLInformationTranfer msg is blocked by any problems encountered by SRB2, this may need some further discussion. |
| NEC | SRB2 | Rel-16 mechanism can be reused. |
| Futurewei | Please see comment | No strong opinion on which SRB to use. However, we support a solution that maximizes commonality of solutions for scenarios 1 & 2.  |
| Huawei | SRB2 | Prefer to reuse the R16 principle.To clarify this should be using SRB2 if established, otherwise using SRB1. |
| vivo | SRB2 | R16 mechanism can be reused to carry F1-C traffic. |

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?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| LG | Yes | A new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information.  |
| Kyocera | Yes | We assume Rel-16 solution can be reused.  |
| Fujitsu | Yes | Reuse R16 F1-C over LTE solution for NR-DC. |
| Ericsson | Too early to decide | We can discuss during stage-3 whether to use a DL/ULInformationTransfer message or a dedicated message. |
| Samsung | Too early to decide | Each candidate RRC messages has their own allowed SRB type(s) in current RRC specification, and it is better to keep the allowed SRB type in order to minimize standardization effort. Therefore this discussion should wait until we’ve settled on (as Ericsson points out) any additional stage-3 details to do with required messaging. |
| NEC | Yes | Rel-16 mechanism can be reused. |
| Futurewei | Too early to decide | Agree with E/// and SS. We should discuss the details of which message to use in stage-3. |
| Huawei | Yes |  |
| vivo | See comments | The Rel-16 solution can be reused, but we tend to agree that this is a stage-3 issue and is no hurry to decide at this stage. |

**Q1c: Are there other aspects (e.g. RRC changes) to be considered for scenario 1?**

|  |  |
| --- | --- |
| 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. |
| Samsung | 1. F1-c path indication (MN, SN, both) as proposed by Qualcomm immediately above is an intuitive option. However, we prefer to use (MCG, SCG, both), which is more straightforward since each leg is referring to a cell group. On the other hand, do we need consider some future-proofing method in case multiple connectivity is allowed in the future?2. F1-C transmission via SNAfter we define the NR RRC for F1-C, at SN side, the IAB-MT can have two choices for F1-C traffic transmission, i.e., NR RRC and BH RLC CH. If we didn’t do anything, the IAB-MT could choose either NR RRC or BH RLC CH for F1-C transfer. Some options for a normative solution to this choice:* Option 1: Use BH RLC CH as long as it is configured for F1-C traffic: this may need some clarification in the specification
* Option 2: Use an explicit indication from the SN.

Please note that we didn’t face this issue for the EN-DC case. In EN-DC case, only LTE RRC is impacted by the F1-C transfer; thus, at en-gNB side, only BH RLC CH can be used.3. Indication of default F1-C path. Currently f1c-Transferpath field is optional and indicates NR leg if absent. However both current scenarios have NR leg for both MCG/SCG leg. So, we need to correct this. Basic assumption is that default f1c-path is the link on Donor node side. On the donor node side we need to check the Bap-config field in RRCReconfiguration message. If RRCReconfig msg including BAP-config is located in mrdc-SecondaryCellGroup field or is transferred via SRB3, then this means donor node is SN. If RRCReconfig msg including BAP-config is not in those above, i.e., just under the outer RRCReconfiguration msg, then this means donor node is MN. Since BAP-config is signaled early on at IAB node setup, it is easy to identify which path is the efault one by using this location info of BAP-config. |
| Huawei | Generally agree with QC, but we should discuss those issue later after we conclude the message and SRB. |
| vivo | The F1-C path should be configurable, i.e., the CU needs to indicate the IAB-node which path (MN, SN, or both) is selected to transfer the F1-C traffic. |

### 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?**

|  |  |  |
| --- | --- | --- |
| 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. |
| Kyocera | [Both] | We have no strong opinion, but we think Rel-16 DCCA supported both split SRB1 and SRB3 for Fast MCG Recovery, i.e., “*MCGFailureInformation*”. So, we wonder if it’s possible that both SRBs are optionally supported. It’s up to NW implementation which SRB is used, i.e., choice case by case.  |
| Fujitsu | Split SRB | To be consistent with scenario 1, it’s better to enhance *DLInformationTransfer* and *ULInformationTransfer* for scenario 2 as well. Therefore, split SRB in option 2 is preferred. |
| Ericsson | Split SRB | The F1-C traffic is terminated in the MN, hence it is more natural to use split SRB which is terminated in the MN (unlike SRB3). Also, the split SRB request is already supported over the Xn, whereas the SRB3 request only applies to MCG recovery in legacy. Hence, split SRB is expected to require less specification effort than SRB3 in RAN3.Additionally, with split SRB, the donor CU can decide whether to send the F1-C traffic via MN and/or SN which gives more reliability and flexibility. |
| Samsung | Discuss further | Scenario 2 could have SRB3 or split SRB for IAB node to be reached by the donor master node. Each option has its own pros and cons. In addition, as mentioned in our contribution, using split SRB needs specification clarification for primary path. |
| NEC | Both, but SRB3 preferred | We think SRB3 would be easier approach as in Rel-16 F1-C over LTE, but no strong view, both can be used.  |
| Futurewei | Discuss further | Both approaches can work, and as SS has stated, each has its pros and cons.One question we would like to discuss in regards to the split SRB approach: Does this imply that F1-C can be encapsulated within this split SRB and delivered via the MCG path, as well as the SCG path? Or is the proposal to limit the delivery of F1-C over SRB to the SCG path, and simply use the existing Xn solution for split SRBs? |
| Huawei | Split SRB2 | We should use the same RRC message as scenario 1, i.e. *ULInformationTransfer* |
| vivo | Both | Both options can work, we think the flexibility of the usage of SRBs should be left to NW’s implementation. |

**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. |
| Kyocera | We think it’s up to RAN3, but assume Rel-16 DCCA solution can be reused, e.g., TS38.423 specifies “*If the Requested Fast MCG recovery via SRB3 IE set to "true" is included in the S-NODE ADDITION REQUEST message and the S-NG-RAN node decides to configure fast MCG link recovery via SRB3 as specified in TS 37.340 [8], the S-NG-RAN shall, if supported, include the Available fast MCG recovery via SRB3 IE set to "true" in the S-NODE ADDITION REQUEST ACKNOWLEDGE message.*” |
| Ericsson | This is a RAN3 issue. It should be up to RAN3 to define how the MN requests SRB3 establishment to the SN. We note that SRB3 request only applies to MCG recovery in legacy Xn specification, hence Xn specification impact is expected. |
| Samsung | Xn signaling needs to be modified in order to ask SN to configure SRB3 for the IAB node, and some related signaling modification is expected (e.g. put such an indication in the XnAP message as an explicit indication). This is a RAN3 matter. |
| NEC | SRB3 should be established before the transmission of F1-C |
| Futurewei | Seems like an issue that should be discussed by RAN 3. |
| Huawei | Maybe we can assume SN always establishes SRB3, in case non-donor SN is deployed together with donor MN. |
| vivo | This is up to RAN3 decision. |

**Q2c: Do you agree that NR *DLInformationTransfer* and *ULInformationTransfer* need to be enhanced to transfer F1-C related information in case of split SRB?**

|  |  |  |
| --- | --- | --- |
| Company | SRB used | Comment |
| LG | Yes | Anyway, a new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information. |
| Kyocera | Yes | We assume the same solution as in Q1b.  |
| Fujitsu | Yes | Same enhancement as in scenario 1. |
| Ericsson | Too early to decide | We can discuss during stage-3 whether to use a DLInformationTransfer message or a dedicated message. |
| Samsung | Yes if… | We are ok with this direction *if we agree* on using split SRB for F1-C traffic. |
| NEC | Yes | F1-C information should be included in ***DLInformationTransfer*** and ***ULInformationTransfer*** |
| Futurewei | Too early to decide | As indicated in the response to Q1b, this seems more appropriate to decide in stage-3.However, as we also indicated in the response to Q1a above, we would prefer a solution that maximizes commonality of solutions for scenarios 1 & 2. |
| Huawei | Yes |  |
| vivo | See comments | This is a stage-3 issue and is no hurry to decide at this stage. |

**Q2d: Do you agree that NR *DLInformationTransferMRDC* and *ULInformationTransferMRDC* need to be enhanced to transfer F1-C related information in case of SRB3?**

|  |  |  |
| --- | --- | --- |
| Company | SRB used | Comment |
| LG | Yes | Anyway, a new IE, .e.g, *DedicatedInfoF1c*, needs to be defined to carry F1-C information. |
| Kyocera | Yes | We think current *DLInformationTransferMRDC* and *ULInformationTransferMRDC* cannot include F1-C related information, since for NR these only have *dl-DCCH-MessageNR* IE and *ul-DCCH-MessageNR* IE respectively. So, we assume some enhancement is needed.  |
| Fujitsu | Yes | In this case, we need to enhance *DLInformationTransferMRDC* and *ULInformationTransferMRDC* to support F1-C transfer. |
| Ericsson | Too early to decide | Details should be discussed during stage-3. |
| Samsung | Yes if… | We are ok with this direction *if we agree* on using SRB3 for F1-C traffic. |
| NEC | Yes  | F1-C information should be included in ***DLInformationTransferMRDC*** and ***ULInformationTransferMRDC*** |
| Furturewei | Too early to decide | As indicated in the response to Q1b, this seems more appropriate to decide in stage-3.However, as we also indicated in the response to Q1a above, we would prefer a solution that maximizes commonality of solutions for scenarios 1 & 2. |
| Huawei | No | Prefer to use the same RRC message for two scenarios. And, it may require to define a new RRC message carrying F1 to be included in the *ULInformationTransferMRDC*, as legacy design.*ULInformationTransferMRDC*The *ULInformationTransferMRDC* message is used for the uplink transfer of MR-DC dedicated information (e.g. for transferring the NR or E-UTRA RRC *MeasurementReport* message, the *FailureInformation* message, the *UEAssistanceInformation* message, the *RRCReconfigurationComplete* message or the *MCGFailureInformation* message).ULInformationTransferMRDC ::= SEQUENCE { criticalExtensions CHOICE { c1 CHOICE { ulInformationTransferMRDC ULInformationTransferMRDC-IEs, spare3 NULL, spare2 NULL, spare1 NULL }, criticalExtensionsFuture SEQUENCE {} }}ULInformationTransferMRDC-IEs::= SEQUENCE { ul-DCCH-MessageNR OCTET STRING OPTIONAL, ul-DCCH-MessageEUTRA OCTET STRING OPTIONAL, lateNonCriticalExtension OCTET STRING OPTIONAL, nonCriticalExtension SEQUENCE {} OPTIONAL} |
| vivo | See comments | This is a stage-3 issue and is no hurry to decide at this stage. |

**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. |
| Kyocera | We’re wondering if Q2e should be really considered, i.e., the activation of CP-UP separation always needs either SRB3 or split SRB.  |
| Fujitsu | Then scenario 2 is not supported. |
| Ericsson | Agree with above comments. |
| Samsung | We think at least one of these needs to be supported in order to support scenario 2. |
| NEC | I don’t think scenario can be supported without SRB3 or split SRB |
| Futurewei | Agree with comments above |
| Huawei | At least split SRB1 is always there. Not sure about the point of this issue. Still, we are fine to not support scenario2. |
| vivo | If CP/UP separation is required for scenario 2, then either SRB3 or split SRB should be available. |

**Q2f: Are there other aspects (e.g. RRC changes) to be considered for scenario 2?**

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| --- | --- |
| Company | Comment |
| Samsung | Please see our answer to Q1c. |
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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:

|  |
| --- |
| 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

|  |
| --- |
| **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.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Huawei | We need to clarify the relationship with option 3/4/5 (or the motivation to introduce option 3/4/5), if option 1 can be considered as the approach to avoid any BAP address collision with minor impact. Does it mean other options is needed in case OAM-based BAP address separation is not deployed? |
|  |  |

### 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.**

|  |  |
| --- | --- |
| **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. |
| Kyocera | We concern about the increasing overhead since all the data needs to have the extended BAP header.  |
| Fujitsu | Firstly, we think BAP address collision is absolutely a valid problem. Secondly, we don’t think extending BAP address with a CU identifier is the suitable approach since it increases the BAP packet overhead while we have other choices without doing so.We also want to point out that even if the BAP address collision is solved, there is still problem on path id used in BAP routing. Currently path ids in two topologies are independently assigned by each CU. How to assign or map path id for the cross-topology routing path needs to be addressed. |
| Ericsson | This solution implies extra overhead in the BAP header, and standardization work needed to modify the BAP header. Additionally, whenever this inter-CU functionality is enabled for any IAB node in the CU1 network, all the IAB nodes in CU1 and CU2 need to be reconfigured a provided with a new CU-id, which is certainly not desirable. In general, the scenario of inter-topology routing should not occur very often, hence RAN2 should aim at minimum standard changes.We also note that the main problem to be addressed in this section is not (only) the “BAP address collision”. Rather, how to properly configure the boundary node, i.e. IAB3, such that it can do the inter-topology routing as depicted in Figure 1a.**Figure 1b-left**: collisions between donor IAB addresses should be a rare event.**Figure 1b-center**: we do not believe that there is any problem with that. Even if there is a BAP address collision between an IAB3’s descendant node and other IAB nodes in the CU2, that should not be a problem. CU2/DU2 just needs to forward the traffic coming from CU1 to the boundary node, and then the boundary node can forward the traffic to the intended descendant, according to the routing tables previously configured by CU1.**Figure 1b-right:** The collision event should be rare. As said, the main issue should be how to properly configure the boundary node, i.e. IAB3, such that it can do the inter-topology routing as depicted in Figure 1a. |
| Samsung | This is a workable solution from RAN2 perspective.The obvious flaw of this option is that each packet over the BH link should additionally contain a CU-related identifier. To ensure the uniqueness, CU-related identifier cannot be very short. Thus, this option will result in large additional load over the network. |
| NEC | We also have the concern of increasing the BAP header. BAP header rewriting is preferred.  |
| Futurewei | Although this is a feasible approach, we also have similar concerns as other companies regarding additional overhead of a CU specific identifier. However, the more significant concern is the impact to BAP routing functionality, and how the routing configuration may need to be changed at many IAB nodes. |
| Huawei | There could be not so many CUs adjacent. CU ID could be short.Before we go with this approach, an elegant BAP header design should be provided first, to reduce the overhead and impact to BAP header.  |

### 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.**

|  |  |
| --- | --- |
| **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. |
| Fujitsu | It seems to be workable. The limitations are: 1) the restriction of the BH RLC channel usage; 2) the boundary IAB node, its descendant IAB nodes and IAB nodes on the redundant path have to maintain two sets of routing tables (more configuration overhead). |
| Ericsson | This solution requires a lot of coordination between CU1 and CU2 to negotiate the new LCIDs such that there is no ambiguity across the two topologies. Additionally, similar to the previous approach, all the IAB nodes in CU2 need to be reconfigured with new set of LCIDs and routing tables to reach the boundary node and the descendants. Also the descendant nodes need to be reconfigured with new LCIDs/routing table to communicated with the DU2.Since the scenario of inter-donor routing should not occur often, RAN2 should aim at a simple solution and minimum standard changes. |
| Samsung | This is a workable solution from RAN2 perspective. This option results in the following issues:Reduce the eLCID space for the topology offering loading offloadingIn this option, the eLCID space applicable for own traffic in topology 2 has to be shrunk since some eLCIDs have to be reserved for the nodes in topology 1 (e.g., IAB node 3&4). Moreover, the available eLCID space for the nodes in topology 2 will be reduced with the increase in the number of nodes with traffic offloading from topology 1 to topology 2.Cause LCID wasteNormally, if two traffic flows have similar QoS requirement, they can be aggregated together and transmitted via the same BH RLC CH. However, in this option, if two traffic flows with similar QoS requirement belong to different topologies, two separate LCIDs have to be assigned. For example, in Fig. 3 (middle), for the BH link between donor DU2 and IAB node 2, LCID=i serves traffic towards IAB node 4, and LCID=j serves traffic towards IAB node 5. Because those two traffic flows belong to different topologies, two different LCIDs have to be assigned, even though those two traffic has the same QoS requirement and can be aggregated into one logical channel. Thus, this option results in LCID waste.In addition, this option requires multiple routing table configurations, each of which is referring to one single topology. |
| Futurewei | This approach seems rather messy and is probably even more complex to implement in the spec than Option 3a. E/// and SS have raised several potential issues with this approach above. Also, it seems that the LCID space would somehow need to be partitioned between the two CUs. It’s not so clear how this would work. Would the partitioning be defined by OAM? If so, then it is not clear that this approach is any different than Option 1, other than having significantly more spec impact. |
| Huawei | Not prefer.This is more like to use the “set ID of BH RLC” to indicate the CU ID. Also, it requires separate routing table configurations. It brings much spec impact to BAP.Not sure how it works in local re-routing. |

### 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.**

|  |  |
| --- | --- |
| **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. |
| Fujitsu | While the details need more discussion, this option has the advantage of limiting the configuration to the boundary node. The BAP routing across topologies is transparent to the descendant node(s) and the nodes on the redundant path (i.e., no additional work is needed on top of Rel-16 scheme). |
| Ericsson | This solution requires no coordination between CU1/CU2 and just little reconfigurations. CU2 can provide independently (without coordinating with CU1) the BAP configuration/address to the IAB3, and then inform CU1 about it.Only the IAB3 needs to be reconfigured to communicate with DU2, while the descendant nodes of the boundary node would not be affected at all (no reconfiguration/routing tables update is needed). The new parent nodes controlled by the CU2, just need to get from the CU2 a new destination entry for the IAB3 in the routing table. Hence, unlike the other approaches, just little reconfigurations are required. Regarding Figure 4-left, we do not believe that in UL, the IAB4 needs to change the BAP destination to A3 for the traffic intended to the CU2. It can still use A1 as destination, and then the IAB3 can use the ingress BH RLC channel or the ingress BAP routing ID to re-route the traffic to DU2. |
| Samsung | This is a workable solution from RAN2 perspective. It is unclear to us the potential for overload to the current BAP routing ID space mentioned by Rapporteur. Normally, for UL traffic from boundary/descendant node, the BAP routing ID contains the BAP address of Donor DU1. However, to differentiate PDUs towards topology 2 from the ones towards to topology 1, the donor CU1 can configure BAP routing IDs by including BAP address (e.g., A10) different from donor DU1. Thus, when the boundary IAB node receives PDUs with BAP address of A10, it can know the BAP rewriting should be performed. In this sense, the BAP routing ID space toward donor DU 1 remains the same.In our opinion, this option keeps the same flexibility as the “normal” case, i.e., each donor CU can manage its own topology independently. |
| Futurewei | This approach seems to have potentially the least spec impact, with changes mostly limited to configuration of routing at boundary IAB node, and additional functionality. This disadvantage seems to be that the boundary IAB node has more work to do to those packets whose headers it needs to re-write.An alternative approach could be for end nodes (donor DU 2 and serving IAB node) to concatenate IAB headers, and then the boundary IAB node could simply strip away the outer header rather than re-writing it. However, it’s not very clear that this would be more any more efficient for the boundary node.  |
| Huawei | Separate BAP address to the boundary node is still FFS. There could be other approach to identify the traffic for the second topology.Considering we are going to support the inter-donor-DU re-routing, it seems BAP header re-writing (e.g. option 4/5) is inevitable anyway.In addition, “routing ID 1:1 remapping” seems not applicable to the case that two DL traffics using the same path in first topology but designating to different IAB nodes in second topology. |

### 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.**

|  |  |
| --- | --- |
| **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. |
| Fujitsu | This option involves IP header interpretation at boundary IAB node, which is a big change over R16. This will bring too much work to both RAN2 and RAN3. |
| Ericsson | Similar to the solution above, also this solution requires little signalling from RAN2 point of view. Only the boundary node IAB3 needs to get a new BAP configuration and routing table to operate under CU2. The descendant nodes would not be affected, and the new parent nodes controlled by the CU2 just need to get from the CU2 a new destination entry for the IAB3 in the routing table.Anyhow, since this solution operates at IP layer, RAN2 standardization impact seems also little, and RAN3 should drive it. |
| Samsung | This option is not workable based on Rel-16 design. The boundary node is acted as intermediate IAB node for descendant nodes. In Rel-16 IAB, the protocol stack for both CP and UP are given as below:The two figures show that the intermediate IAB node (i.e., IAB-node 1) does not process the IP headers of the received packets. However, Option 5 requires the boundary node to decode the whole IP header, which requires the design of a new protocol stack for Rel-17 eIAB. |
| Futurewei | Not clear that this approach has any advantage compared to Option 4. The boundary IAB node still needs to rewrite the BAP header so that the packet can be routed in the other topology. On the other hand, the impact to the BAP specification would be increased relative to Option 4. |
| Huawei | As to the configuration to the access node on flow lable/DSCP marking, legacy signalling design can be reused in the Xn message for R16 EN-DC case.We may need the unified solution with the bearer mapping at the boundary node. IP header based routing ID rewriting and bearer mapping is the flexible way.Please note that routing ID based rewriting means multiple traffic using the same path in CU2 has to also use the same path in CU1 (routing IDx=>routing IDy). This gives much restriction on the routing/path configuration in CU’s own topology. |

### 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.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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. |  |  |  |  |
| Kyocera | [1] |  | 3 | 1 | 2 |
| Fujitsu |  |  | 2 | 1 |  |
| Ericsson | [1] OAM can never be precluded. | - | - | 1 | 2 |
| Samsung | Out of scope for normative work | - | - | 1 | - |
| NEC | [1] OAM can never be precluded. |  | 2 | 1 | 3 |
| Futurewei | OAM can not be excluded. However, as SS points out it does not involve any normative work. | 2 | - | 1 | - |
| Huawei | 1 | 3 | - | 2 | 1, in case option1 is not deployed |
| vivo | [1] |  |  | 1 |  |

### 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.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Fujitsu | We don’t think that ingress-to-egress BH RLC channels are required to be mapped 1:1 at the boundary node. Anyway, we think the final choice of the inter-topology BAP routing may have impact on the bearer mapping at the boundary node. We may discuss the bearer mapping after the decision on the inter topology BAP routing. |
| Ericsson | We are also not sure that this RAN3 agreement implies a 1:1 mapping of BH RLC channels at the boundary node. We assume the decision is up to CU1 which still is in control of how to map the UL ingress channels to UL egress channels (indicated by CU2) and DL ingress channels (indicated by CU2) to DL egress channels |
| Samsung | At this stage, we can start from 1:1 mapping.In case the Option 4 is selected, the BAP header rewriting configuration can be used by the boundary IAB node to select the correct route for the received packets. After that, the ingress-to-egress BH RLC CH mapping can follow Rel-16 design. |
| Futurewei | Not clear that the RAN3 agreement implies any restriction of RLC channel mapping at the boundary node.Generally, we agree with E///’s comment above. |
| Huawei | Not fully agree “has the implication that ingress-to-egress BH RLC channels are mapped 1:1 at the boundary node.” The R3 agreement only mean the all setup BH RLC information will be shared between CUs.The “ingress RLC to egress RLC at boundary node” solution means the restriction that the multiple bearers aggregated to one BH RLC in CU1 should also be aggregated to one BH RLC in CU2. In that sense, “IP header to egress RLC mapping” should be more flexible. |

# Phase 2

…

# Conclusion

* …

# References

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