**3GPP TSG-RAN WG2 #117-e *R2-21xxxxx***

Electronic meeting, Feb 21 – Mar 3, 2022

Agenda Item: X.X.X

Source: Xiaomi

Title: Summary of [Post116-e][604][Relay] Remaining issues on service continuity (Xiaomi)

Document for: Discussion and Decision

# Introduction

This contribution is to kick off following email discussion,

* **[Post116-e][604][Relay] Remaining issues on service continuity (Xiaomi)**

Scope: Discuss the remaining issues on service continuity:

* Measurement configuration and reporting:
  + Whether to consider S-measure criterion based on RSRP of serving relay and other AS criteria for indirect-to-direct path switch (P8-1/P8-2 of R2-2111276)
  + Whether to consider AS criteria for measurement when performing SL measurement for path switch (P7-1 of R2-2111276)
  + Whether to have allow-list and block-list of relay UEs (or serving cells of relay UEs) (P3 of R2-2111276)
  + Whether to have new events in addition to Event X and Event Y (serving relay/neighbour cell for indirect-to-direct, candidate relay for direct-to-indirect) (P6 or R2-2111276)
  + Which ID to report for serving cell of relay UE (NCGI/NCI/PCI) (P10 of R2-2111276)
  + Relay UE ID to include in measurement report and how the network learns the ID (P9-1/P9-2 of R2-2111276)
  + Conclude on the proposal that relay (re)selection is not performed by an RRC\_CONNECTED L2 remote UE, except for the RLF case (P11 of R2-2111276)
* Determine an option for ensuring UL PDCP lossless behaviour in indirect-to-direct path switch (P26 of R2-2111276):
  + Option 1: No spec impact, i.e., assume loss of UL PDCP PDUs is a corner case or can be addressed by network implementation
  + Option 2: Remote UE retransmits PDCP SDUs for which the successful delivery of the corresponding PDCP PDU has not been confirmed by PDCP status report after path switch

Intended outcome: Report to next meeting

Deadline: Long

# Discussion

## Measurement configuration and reporting

### S measure criterion in direct to indirect path switch

On Uu, S measure criterion is introduced to save UE power. gNB could configure a RSRP threshold. UE performs measurement if the NR SpCell RSRP is lower than the threshold, otherwise UE does not perform measurement. Note the S measure can only control the measurement of measurement object whose associated *reportType* is *periodical, eventTriggered* or *condTriggerConfig*, which is mainly used for mobility purpose. Related specification could be found as following,

|  |
| --- |
| 2> if the *reportType* for the associated *reportConfig* is *periodical*, *eventTriggered* or *condTriggerConfig*:  3> if a measurement gap configuration is setup, or  3> if the UE does not require measurement gaps to perform the concerned measurements:  4> if *s-MeasureConfig* is not configured, or  4> if *s-MeasureConfig* is set to *ssb-RSRP* and the NR SpCell RSRP based on SS/PBCH block, after layer 3 filtering, is lower than *ssb-RSRP,* or  4> if *s-MeasureConfig* is set to *csi-RSRP* and the NR SpCell RSRP based on CSI-RS, after layer 3 filtering, is lower than *csi-RSRP*:  5> if the *measObject* is associated to NR and the *rsType* is set to *csi-rs*:  6> if reportQuantityRS-Indexes and maxNrofRS-IndexesToReport for the associated reportConfig are configured:  7> derive layer 3 filtered beam measurements only based on CSI-RS for each measurement quantity indicated in *reportQuantityRS-Indexes*, as described in 5.5.3.3a;  6> derive cell measurement results based on CSI-RS for the trigger quantity and each measurement quantity indicated in *reportQuantityCell* using parameters from the associated *measObject*, as described in 5.5.3.3;  …… |

P8-1 in [1] propose to discuss whether S-measure criterion based on RSRP of serving relay could be introduced during indirect to direct path switching. Namely, gNB could configure SL-RSRP threshold. Remote UE doesn’t perform measurement on Uu if the serving relay UE’s SL-RSRP is higher than the threshold, otherwise remote UE performs measurement on Uu.

**Q1: Do you agree to introduce S-measure criterion based on SL/SD-RSRP of serving relay during indirect to direct path switching.**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes | Measurements for service continuity should use Uu measurements as a baseline. So s-measure should be supported for the same benefits (power savings) as in Uu. |
| OPPO | No | Since even the relay link is good enough, remote UE may still like to switch to direct link since it can acquire better performance. Besides, it may be also that the Uu-link of relay is not good, so relay searching by remote UE is still beneficial for possible Uu-RLF of relay. |
| Xiaomi | Yes | S measure could save UE power by reducing measurement on Uu, in case the radio channel quality between remote UE and relay UE is good enough. |
| Qualcomm | No | Same view as OPPO. In addition, we don’t think it is an essential issue to address in first release of SL relay. |
| Ericsson | No | Same view as Qualcomm and OPPO. |
| LG | No | Same view as OPPO |
| Huawei, HiSilicon | No | Similar view as above, seems not an urgent issue for this release. |

If S-measure is preferred in Q1, P8-2 in [1] further propose to discuss whether measurement result other than SL-RSRP could be used to control remote UE performing measurement on Uu, e.g. CBR

**Q1-1: Do you agree to introduce S-measure criterion based on other measurement result.**

**Option 1: CBR**

**Option 2: Other**

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| --- | --- | --- |
| Company | Option | Comments |
| InterDigital | Yes | This would be beneficial since SL RSRP only does not define whether a relayed link is preferred over a direct link. We think we should support this as long as we keep the rule simple (e.g. a single CBR threshold configured by the network). |
| Xiaomi | No | CBR is used to control resource selection and congestion control, which doesn’t reflect the radio channel quality. Therefore, it’s not aligned with S measure principle. |
| LG | No |  |

### AS criteria for measurement report when performing SL measurement for path switch

P7-1 in [1] propose to discuss whether AS criteria for measurement report should be considered when performing SL measurement for path switch.

Rapporteur understands following options were discussed by companies as AS criteria during SL measurement report for path switch,

Option 1: The configured measurement report event.

Option 2: The SD-RSRP/SL-RSRP threshold used in relay selection/reselection.

Option 1 is aligned with legacy behavior. Remote UE shall report relay UEs, whose measurement result fulfills the configured report event. Option 2 introduce additional filtering of relay UE based on threshold for relay selection/reselection. Even the relay UE, whose measurement result fulfills the measurement report event, may be filtered out by SD-RSRP/SL-RSRP threshold, since the two AS criteria are configured independently. This may result in measurement report is triggered, but no relay UE is included.

**Q2: Do you agree the Remote UE does not consider the AS criteria for measurement report when performing SL measurement for path switch, except for configured measurement report event.**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes | Measurement thresholds related to relay selection/reselection should not be used in measurement reporting. |
| OPPO | Yes (i.e., not consider) |  |
| Xiaomi | Yes |  |
| Qualcomm | Yes | We agree with Rapporteur’s analysis. And it is aligned with Uu RRM principle. |
| Ericsson | Yes |  |
| LG | Yes |  |
| Huawei, HiSilicon | Yes |  |

### Allow-list/Block-list of relay UE

In Uu, the network may configure a list of cell specific offsets, a list of 'blacklisted' cells and a list of 'whitelisted' cells. Blacklisted cells are not applicable in event evaluation or measurement reporting. Whitelisted cells are the only ones applicable in event evaluation or measurement reporting. How to set the list is up to NW implementation. With these lists, power consumption and signaling overhead could be saved by avoidance of unnecessary event evaluation or measurement report. Rapporteur understands Whitelist/Blacklist cells is legacy procedure and supported during indirect to direct path switch, without spec impact. Rapporteur would like to clarify the understanding of legacy blacklist/whitelist cell applicability.

**Q3: Do you agree the legacy blacklist/whitelist cells is supported during indirect to direct path switch, without spec impact.**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes |  |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Qualcomm | Yes |  |
| Ericsson | Yes |  |
| LG | Yes |  |
| Huawei, HiSilicon | Yes |  |

Following the same logic, during direct to indirect path switch, certain relay UEs may not be suitable to access due to overload or other NW implementation. gNB would not switch remote UE to these relay UEs. It’s unnecessary for remote UE to evaluate event and report these relay UE’s measurement result, which results in power wasting and signaling overhead. Therefore, companies proposed to introduce allow-list/block-list during direct to indirect path switch. Namely, Relay UEs indicated by block-listed are not applicable in event evaluation or measurement reporting. Relay UEs indicated by allow-list cells are the only ones applicable in event evaluation or measurement reporting.

**Q4: Do you agree to introduce Allow-list/Block-list of relay UE during direct to indirect path switch. Namely, Relay UEs indicated by block-listed are not applicable in event evaluation or measurement reporting. Relay UEs indicated by allow-list cells are the only ones applicable in event evaluation or measurement reporting.**

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| Company | Y/N | Comments |
| InterDigital | Yes | This is a logical extension of Uu and can be supported to save power at the remote UE. |
| OPPO | No | Do not think this is a critical issue at this late stage. If network would like to prevent the accessibility of some relay UEs, network can direct avoid to provide relay configuration towards those relay UEs so that remote UE will not detect the discovery of those relay UEs. On the other hand, those relay UE which can be detected by remote UEs should be within the allow-list by default. |
| Xiaomi | Yes | Allow-list/Block-list could save UE power by avoiding unnecessary measurement and report on the relay UEs, which is not suitable for path switching. |
| Qualcomm | No | Same view as OPPO (i.e., it is not an essential issue to be addressed in this release). Furthermore, we have below 2 concerns/comments:   1. As agreed in last RAN2 meeting, Remote UE performs report filtering based on upper layer criteria because upper layer info of relay UE is not aware by remote UE. Then, following same logic, we questioned how gNB can determines such list by itself. If such list is introduced, do we need to further specify how relay coordinates with gNB on generating this list? 2. At least Allow-list (similar to whitelist) is not needed. Please note that blacklist was introduced in Rel-8 but whilelist was introduced in Rel-13 for a particular use case. We don’t see such case should be considered in L2 relay. |
| Ericsson | No | Not necessary to be introduced, at least in this release. |
| LG | No | Allow-list/block-list of relay UE can be handled by discovery message. If the relay UE is in a block-list, for example, cause of overload, the relay UE may not transmit discovery message. So, we think the allow-list/block-list of relay UE is not necessary. |
| Huawei, HiSilicon | Yes | We understand Allow-list/Block-list can save some unnecessary measurement report and UE power in some cases. For instance, the network may provide the cell ID and relay ID to limit the measurement on intra-gNB relays, please note only network but not UE can differentiate gNB based on CGI. As the configuration and handling of the two list are very straightforward (with not much standard effort), we prefer to have it in this release. |

If Allow-list/Block-list is preferred in Q4, rapporteur suggest to further discuss how to formulate the allow-list/block-list. Two options were proposed by companies,

Option 1: Allow-list/Block-list include relay UE’s serving cell ID. Remote UE could identify whether one relay UE is indicated by allow or bloc list by its serving cell ID included in discovery message.

Option 2: Allow-list/Block-list include relay UE ID. Remote UE could identify whether one relay UE is indicated by allow or block list by its relay UE ID included in discovery message.

To determine how to set the list, NW shall be aware of the necessary information of each element in the list, e.g. load information. In option 1, NW shall be aware of each cell related information, which is already supported in legacy. NW could set the allow-list/block-list in similar way as legacy black/white cell. In option 2, NW shall be aware of relay UE related information, which may be provided by relay UE’s report.

**Q4-1: Which option do you prefer to formulate the allow-list/block-list,**

**Option 1: Allow-list/Block-list include relay UE’s serving cell ID.**

**Option 2: Allow-list/Block-list include relay UE ID.**

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| Company | Option | Comments |
| InterDigital | Option 1 or 2 | Either option could work for an RRC\_CONNECTED relay, since the NW is aware of the association between relay UE and serving cell when the relay is in RRC\_CONNECTED. |
| Xiaomi | Option 1 | Option 1 is more aligned with legacy procedure and can apply to relay UE in all RRC states. Option 2 requires gNB to be aware of candidate relay UE’s ID, which may not be applicable to relay UEs in IDLE/INACTIVE. Also, option 2 would require gNB to be aware of relay UE’s information, e.g. load, which may need new report from relay UE. |
| Huawei, HiSilicon | Option 1 and 2 | We share the similar view with InterDigital, option 1 is more useful for IDLE/INACTIVE relay, option2 have finer granularity. So both options are useful. |

### New events in addition to Event X and Event Y

During indirect to direct path switch, Event X is agreed. In addition, following events were proposed by companies,

Option 1: serving relay is worse than a threshold,

Option 2: neighbor Uu cell is offset better than serving relay.

Option 1 is similar as Event A2 on Uu. Option 2 is similar as Event A3 on Uu. However, since measurement on Uu and SL is based on different reference signal, it’s unclear whether it’s appropriate to directly compare the measurement result on Uu and sidelink.

**Q5: which event do you prefer to introduce during indirect to direct path switch,**

**Option 1: serving relay is worse than a threshold,**

**Option 2: neighbor Uu cell is offset better than serving relay**

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| --- | --- | --- |
| Company | Option | Comments |
| InterDigital | Option 1 and 2 | For option 2, the gNB can compensate for difference in reference signal based on proper configuration of the offset. |
| OPPO | Option 1 | For option 2, it is very unreasonable to compare Uu signal and PC5 signal in a direct way since the RS design, as well as power control strategy for the channels in these two interfaces are totally different. |
| Xiaomi | Option 1 | We are not sure whether it’s appropriate to directly compare the measurement result on Uu and sidelink. |
| Qualcomm | Option 1 | Same view as OPPO and Xiaomi.  In addition, we want to confirm that Option 1 is actually S2 event introduced in Rel-16, right? Then, no new event is required to be introduced. |
| Ericsson | Option 1 and Option 2 |  |
| LG | none | We think none of option1 and option 2 do not need to specify some events. If option 1 happens, the operation of remote UE should be left on the UE implementation. Option 2 is not proper to compare Uu link and SL directly. |
| Huawei, HiSilicon | Option 1 |  |

During direct to indirect path switch, Event Y is agreed. In addition, following events were proposed by companies,

Option 1: candidate relay is better than a threshold,

Option 2: candidate relay is offset better than serving Uu cell,

Option 3: CBR as well as SL and/or Uu radio signal measurements.

Option 1 is similar as Event A1 on Uu. Option 2 is similar as Event A3 on Uu. However, same as above, it’s unclear whether it’s appropriate to directly compare the measurement result on Uu and sidelink. Option 3 introduce new event, which combine the CBR and SL/Uu radio signal measurement. Rapporteur understands two thresholds should be defined, which are used to compare the CBR and SL/Uu radio signaling measurement result respectively.

**Q6: which event do you prefer to introduce during direct to indirect path switch,**

**Option 1: candidate relay is better than a threshold,**

**Option 2: candidate relay is offset better than serving Uu cell,**

**Option 3: CBR as well as SL and/or Uu radio signal measurements.**

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| Company | Option | Comments |
| InterDigital | Options 1, 2, and 3 | For option 2, the same comments as in Q5 apply. For option 3, we agree with rapporteur that a separate CBR threshold should be configured for such events. |
| OPPO | Option 1 | For option 2, similar comment as above.  For option 3, CBR is a per resource pool measurement/configuration, which is only used for congestion control and resource selection and has no relationship to service continuity. |
| Xiaomi | Option 1 | For option 2, We are not sure whether it’s appropriate to directly compare the measurement result on Uu and sidelink.  For option 3, agree with OPPO. |
| Qualcomm | None or Option 1 | Uu A4 event is not an important one. As long as we have A2 (serving cell is worse than one threshold) and new event Y, we think their combination can handle all scenarios.  However, if majority prefer to introduce Option 1, we can accept. |
| Ericsson | Options 1, 2, and 3 |  |
| LG | None | Same answer on the Q5. Option 3 is not proper because CBR is for resource selection and scheduling. |
| Huawei, HiSilicon | Option1 |  |

### ID to report for serving cell of relay UE

It was agreed that the SL relay measurement report shall include serving cell ID of the Relay UE. In RAN2 #115 meeting, NCI is taken as the WA. However, PCI, NCI and NCGI were proposed by companies. Rapporteur understands all these IDs can work and the major difference is signaling overhead, i.e. PCI is 10 bits, NCI is 36 bits and NCGI is 52 bits (as PLMN ID is 16 bits).

**Q7: which cell ID do you prefer when relay UE report as its serving cell ID,**

**Option 1: PCI,**

**Option 2: NCI,**

**Option 3: NCGI.**

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| Company | Option | Comments |
| InterDigital | No strong view | As mentioned by rapporteur, all of these can work and there is little difference in the signaling overhead. |
| OPPO | Option 2, option 3 | Depend on whether to support RAN sharing, i.e., if no RAN sharing, NCI is sufficient, otherwise, NCGI including PLMN ID is needed. |
| Xiaomi | Option 1 or 2 | We think PCI is enough. If PCI can be reused in neighbor cells, NCI is preferred. |
| Qualcomm | Option 2, option 3 | Same view as OPPO, depending on outcome of whether to support RAN sharing |
| Ericsson | Option 2 |  |
| LG | No strong view | All can work |
| Huawei, HiSilicon | Option 2 | To clarify, the question is **which cell ID do you prefer ~~when relay UE report~~ as ~~its~~ serving cell ID** **of the Relay UE in SL relay measurement report**? |

### Relay UE ID in measurement report

It’s agreed SL relay measurement report can include Relay UE ID. Regarding which ID is included, majority prefer to use relay UE’s source L2 ID according to companies’ contributions in RAN2#116. Rapporteur suggest to follow majority view.

**Q8: Do you agree to use relay UE’s source L2 ID as relay UE ID in measurement result.**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes |  |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Qualcomm | Yes | UE ID in measurement report should be same as the relay UE ID used in discovery message. And SA2 has captured that relay UE ID included in discovery message is Source L2 ID self-selected by the Relay UE in TS 23.304 clause 5.8.3.1. |
| Ericsson | Yes |  |
| LG | Yes |  |
| Huawei, HiSilicon | Yes |  |

If source L2 ID is preferred in Q8, gNB is unable to map the source L2 ID to relay UE, since relay UE doesn’t report its source L2 ID. So, gNB is unable to prepare the relay UE in advance. To enable the mapping, companies proposed for relay UE in RRC\_CONNECTED to report its source L2 ID to gNB.

**Q8-1: Do you agree relay UE in RRC\_CONNECTED reports its source L2 ID to gNB.**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes |  |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Qualcomm | Yes |  |
| Ericsson | Yes but | We think that the relay UE does not needs to be necessarily in RRC\_CONNECTED to report the L2 ID. The reporting can happen in any RRC state as far there is a PC5 connection (for sidelink relay purposes up and running). |
| LG | Yes |  |
| Huawei, HiSilicon | Yes |  |

If companies prefer Y in Q8-1, a following question is which message is used to report source L2 ID.

**Q8-2: which message do you prefer for relay UE in RRC\_CONNECTED to report source L2 ID,**

**Option 1: *SidelinUEInformationNR*,**

**Optoin 2: *UEAssistanceInformation*,**

**Option 3: New message.**

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| --- | --- | --- |
| Company | Option | Comments |
| InterDigital | Option 1 | This is better aligned with current reporting of the L2 ID. |
| OPPO | Option 1 |  |
| Xiaomi | Option 1 |  |
| Qualcomm | Option 1 |  |
| Ericsson | Option 1 but | We think that the relay UE does not needs to be necessarily in RRC\_CONNECTED to report the L2 ID. The reporting can happen in any RRC state as far there is a PC5 connection (for sidelink relay purposes up and running). |
| LG | Option 1 |  |
| Huawei, HiSilicon | Option 1 |  |

### Relay (re)selection performed by RRC\_CONNECTED L2 remote UE

For L2 remote UE in RRC\_IDLE/RRC\_INACTIVE relays, the (re)selection procedure is UE autonomous and triggered based on measurements of SL-RSRP. However, for remote UE in RRC\_CONNECTED, mobility should be controlled by the network. In this case, UE autonomous (re)selection (similar to LTE) should not be performed by the remote UE in RRC\_CONNECTED except for some exceptional cases such as when the remote UE cannot reliably communicate with the network.

**Q9: Do you agree Relay (re)selection procedure is not performed by a L2 Remote UE in RRC\_CONNECTED, except for the case of RLF**

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| --- | --- | --- |
| Company | Y/N | Comments |
| InterDigital | Yes, with comments | Here we understand RLF to be either SL-RLF detected by the remote UE, and Uu-RLF indication sent to the remote UE by the relay UE via PC5-RRC message.  For PC5-S release message, or PC5-RRC message indicating HO by the relay, we think these require further discussion as to whether (re)selection is performed, and whether the remote UE stays in RRC\_CONNECTED in this case. |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Qualcomm | No (at least clarification is needed) | Proponents please clarify below our questions before making summary proposals:   1. We are not sure what “the case of RLF” includes: does it only include PC5 RLF detected by remote UE, or it also includes Uu RLF notified by relay UE via PC5 RRC message? Our understanding is that both cases are included 2. Does exception also include the case that remote UE receives the PC5-S message for release from relay UE? We think it also need to include this exception case. 3. Does exception also include the case that remote UE receives the PC5 RRC message on notification of HO from relay UE? We think it also need to include this exception case.   For above case 2) and 3), please also note that relay UE is not aware of remote UE’s RRC state per current agreements. So, if 2) and 3) are not exception case, RAN2 need to specify how to prevent misalignment between remote UE and relay UE (i.e., relay UE think the PC5 link has been released but remote UE actually doesn’t release because it is in CONNECTED state) |
| Ericsson | Yes |  |
| LG | No | The exceptional case may be included the following cases:   * Relay UE indicates HO to the remote UE * Relay UE indicates Uu RLF to the remote UE   Relay UE performs cell reselection |
| Huawei, HiSilicon | Yes with comments | Our understanding is in the normal connected mode, L2 Remote UE does not need to perform relay (re)selection, but for some exceptional cases trigger Remote UE do RRC reestablishment, the UE needs to find a suitable relay or Uu cell, this is when relay (re)selection can be performed. |

## UL PDCP lossless behaviour in indirect-to-direct path switch

For UL data delivery during the path switch, certain data PDU may be received by the relay UE but not be transmitted to gNB. After path switch, the remote UE may be indicated to do PDCP reestablishment or PDCP data recovery to retransmit the data which has been confirmed by RLC. However, the confirmation from RLC doesn’t reflect the successful reception by gNB. Therefore, UL PDCP lossless may not be ensured.

Regarding how to ensure UL PDCP lossless in indirect-to-direct path switch, the solution seems to be ask remote UE to retransmit the PDCP SDUs according to PDCP status report from gNB.

While some companies think this issue only happens when relay fails to complete the transmission towards gNB, e.g., when gNB release the RLC channel intentionally, or RLF happens in an unexpected manner. Therefore, it’s a corner case.

**Q10: which option do you prefer to ensure UL PDCP lossless in indirect-to-direct path switch,**

**Option 1: No spec impact, i.e., assume loss of UL PDCP PDUs is a corner case or can be addressed by network implementation,**

**Option 2: Remote UE retransmits all the PDCP SDUs for which the successful delivery of the corresponding PDCP Data PDU has not been confirmed by PDCP status report in the target side after path switch.**

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| --- | --- | --- |
| Company | Option | Comments |
| InterDigital | Option 1 | We think a path switch occurring simultaneously with Uu RLF is a corner case and we can avoid special handling of it in this release. |
| OPPO | Option 1 | We agree with rapporteur’s observation that it is a corner case that Uu RLF and path switch occurring simultaneously. |
| Xiaomi | Option 1 |  |
| Qualcomm | Option 1 | We also think it is a corner case. |
| Ericsson | Option 1 |  |
| LG | Option 1 |  |
| Huawei, HiSilicon | Prefer option 2 | The Remote UE’s UL data may loss during Relay UE’s Uu link change, e.g. Uu RLF, Uu HO to the same or other gNB. Although we agree that the above cases may not happen very frequently, but as the solution in option2 is simple and effective, we slightly prefer to adopt it to address the potential issues. |

# Conclusion

# Reference

[1] R2-2111276 Summary of AI 8.7.2.2 Service continuity Huawei, HiSilicon