**3GPP TSG-RAN WG2 #119bis-e *R2-221xxxx***

**E-meeting, October 2022**

Agenda Item: 8.9.4

Source: OPPO

Title: Summary of  [AT119bis-e][426][Relay] Control plane aspects for multi-path (OPPO)

Document for: Discussion, Decision

# Introduction

This is for the following offline discussion.

* [AT119bis-e][426][Relay] Control plane aspects for multi-path (OPPO)

Scope: Discuss P11/P12/P18/P19/P20 of R2-2209375, considering applicability to both scenarios 1 and 2.

Intended outcome: Report to CB session

Deadline: Monday 2022-10-17 1700 UTC

# Discussion

## Scenario

For Scenario, two proposals are provided in 09375

*Proposal 11 For scenario-1 of multi-path relay, R2 does not pursue applying multi-path relay to the procedures of SIB delivery, paging delivery, RRC setup/resume and re-establishment.*

*Proposal 12 For scenario-1 of multi-path Relay, R2 focus on the application of multi-path relay to RRC\_CONNCTED UEs only, i.e., after RRC setup/resume / re-establishment procedure.*

Firstly, to check companies view on the applicability of MP-relay for RRC states.

**Q1-1: Do you think multi-path Relay is applicable to RRC\_CONNECTED remote-UE or not?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | Yes | Yes |  |
| Xiaomi | Yes | Yes |  |
| CATT | Yes | Yes |  |
| Huawei, HiSilicon | Yes | Yes |  |
| vivo | Yes | Yes |  |
| ZTE | Yes | Yes |  |
| Ericsson | Yes | Yes |  |
| Apple | Yes | Yes |  |

**Q1-2: Do you think multi-path Relay is applicable to RRC\_INACTIVE remote-UE or not?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | No | No |  |
| Xiaomi | No | No |  |
| CATT | No | No |  |
| Huawei, HiSilicon | No | No |  |
| vivo | No | No | In our understanding, Multi-path is a concept for Connected UE like CA and DC, which means after configuration in CONNECTED state and not related to IDLE/INACTIVE |
| ZTE | No | No |  |
| Ericsson | No | No |  |
| Apple | No | No |  |

**Q1-3: Do you think multi-path Relay is applicable to RRC\_IDLE remote-UE or not?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | No | No |  |
| Xiaomi | NO | NO |  |
| CATT | No | No |  |
| Huawei, HiSilicon | No | No |  |
| vivo | No | No |  |
| ZTE | No | No |  |
| Ericsson | No | No |  |
| Apple | No | No |  |

Secondly, besides the applicability to the dimension of RRC states, to check companies view on the other dimension, i.e., related RRC procedures.

**Q2-1: Do you think R2 needs to enhance R17 mechanism of SIB-delivery for R18 MP Relay?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | No | No | We do not think MP-Relay is applicable to RRC\_IDLE/RRC\_INACTIVE UEs, where R17 procedure (where the UE can by its implementation to perform the SI reception via direct path besides the indirect path) is sufficient.  Although it is applicable to RRC\_CONNECTED remote UE, we do not think there is a need for specific optimization for it:  If the SIB is delivered via dedicated RRC signaling, then it is a just about split-SRB configuration issue; Or if the SIB is delivered via SIB directly, then UE can acquire the SIB directly if configured with CSS. |
| Xiaomi | FFS | FFS | It’s not clear to us what ‘enhancement’ mean in the question. If we found some thing broken on SIB delivery in multipath, it should be fixed. At this early SI phase, we may need futher study.  [Rapp] If any ‘some thing broken’ identified now? if yes, please clarify  Re: We understand the SIB delivery is only applicable on the path which holds the RRC connection, e.g. anchor path, not on the other path. However, it’s still FFS whether such path differentiation is supported. So, we can’t make conclusion on the SIB delivery for now. |
| CATT | No | No | Agree with OPPO. When the remote UE is configured with multi-path, it is in RRC\_CONNECTED. Therefore, it is not needed to receive SIB/paging forward from the relay UE. |
| Huawei, HiSlicon | No | No | In Rel-17, no SIB deliver for connected Remote UE. We do not foresee any new requirement to enhance this/other aspects related to SIB forwarding for multipath. |
| vivo | No | No with comments | For scenario 1, there is R17 mechanism of SIB-delivery for U2N SL relay scenario, which is reused, e.g. in case of remote UE OOC or with lower RSRP. After establishment of indirect path as legacy R17 procedure, the remote UE enters into RRC CONNECTED state and direct path can be added. In the other direction, when a remote UE enters into RRC CONNECTED state via direct path and then a indirect path is added. In these two basic procedures, the SIB-delivery related the second path is for a CONNECTED UE, i.e. via RRC dedicated signalling as legacy. Nothing new is needed.  For scenario 2, R17 mechanism of SIB-delivery for U2N SL relay scenario cannot be used. However, the SIB-delivery related to the second path is also for a CONNECTED UE, i.e. via RRC dedicated signalling as legacy. For the SIB-acquisition of the first path, remote UE reads directly via direct path or acquires from its relay UE via un-specified inter-UE interface. No specification effort is needed either. |
| ZTE | No | No | As far as we know, it has been specified in Rel-17 that the in-coverage U2N Remote UE is allowed to acquire any necessary SIB(s) over Uu interface irrespective of its PC5 connection to Relay UE. Moreover, the U2N Remote UE can also receive the system information from the Relay UE after PC5 connection establishment with U2N Relay UE. When it comes to the multi-path remote UE in RRC\_Connected UE, it may receive system information from only one of the paths or both paths. Which path to choose can be based on the bearer type configuration of SRB1. |
| Ericsson | No, with question for clarification | No, with question for clarification | The question is a little unclear, are we only considering the indirect path here because the R17 mechanism is only applicable for the indirect path?  Our understanding, for MP, the two paths can be associated to same/different cells. When connected to the different cells, SIB on direct path can be obtained via legacy procedures and on indirect path can be obtained based on R17 mechanism. When connected to the same cell, the remote UE can acquire necessary SIBs on the direct path and other (relay) SIBs over the indirect path or can be left to UE implementation. |
| Apple | FFS | FFS | We think for RRC\_CONNECTED remote UE, the UE can trigger on-demand SI procedure (e.g, transmission *DedicatedSIBrequest*) from either direct path or indirect path, this is related to how SRB1 is configured in MP and whether there is a primary path concept for control plane. Similar question for the NW side, too. |

**Q2-2: Do you think R2 needs to enhance R17 mechanism of Paging-delivery for R18 MP Relay?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | No | No | Since we do not think MP-Relay is applicable to RRC\_IDLE/RRC\_INACTIVE UEs, where R17 procedure (where the UE performs the paging reception via a single path) is sufficient. |
| Xiaomi | No | No | Paging is not applicable for CONNECTED remote UE. |
| CATT | No | No | Multi-path is only applied for the remote UE in RRC\_CONNECTED. Paging forward is not needed. |
| Huawei, HiSilicon | No | No |  |
| vivo | No | No with comments | Similar as the above response in Q2-1, a remote UE with R18 multi-path configuration is always in RRC CONNECTED state. There is no need to introduce paging-delivery solution for a CONNECTED UE.  Furthermore, regarding a IDLE/INACTIVE remote UE before Multi-path establishment in scenario 1, both monitoring paging via direct path or paging-delivery via a R17 U2N relay path are all legacy mechanisms. In scenario 2, if the cases of indirect path firstly establishment or maintaining are supported, e.g. for a OOC remote UE, unspecified paging-delivery mechanism via ideal inter-UE backhaul may be needed without specification impacts. |
| ZTE | No | No |  |
| Ericsson | No | No | The question again is unclear, R17 mechanism only relates to the indirect path?  The same scenario of same/different cells is applicable here. Paging in CONN state is applicable in the case of ETWS warnings and SIB updates. ETWS warnings can be received over the direct path. For SIB updates over the indirect path (on a different cell), like in Rel-17, it is up to the network to provide the updated SIBs |
| Apple | No | No |  |

**Q2-3: Do you think R2 needs to enhance R17 mechanism of RRC setup/resume/re-establishment procedure for R18 MP Relay?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | No | No | R17 procedure (where the UE performs the RRC procedure via a single path) is sufficient. |
| Xiaomi | No for remote UE | No for remote UE | For remote UE, MP is not established during initial access.  For relay UE, we may need further study. If relay UE in IDLE/INACTIVE can be selected during MP addition as in Q4-1, we need to study how to trigger relay UE enter CONNECTED. Legacy procedure may be enhanced. |
| CATT | No for remote UE | No for remote UE | Agree with Xiaomi. Enhancement is needed on how to trigger relay UE in IDLE/INACTIVE enter CONNECTED. |
| Huawei, HiSilicon |  |  | Not so sure about the question, if the only connected UE can be configured with multiple path, the RRC setup/re-establishment/resume procedures seem not relevant. |
| vivo | No | No | Legacy Uu and R17 SL relay procedure for L2 Remote UE on RRC setup/resume/re-establishment, can be considered as baseline in general. |
| ZTE | No | No | For the remote UE, it may perform the RRC setup/resume/re-establishment based on legacy mechanism. We see no motivation for the enhancements. |
| Ericsson | No | No | Same concern for the question. This only relates to the indirect path?  The RRC setup/resume/re-establishment procedures are the same for direct (based on legacy) and indirect path (based on R17 mechanism) |
| Apple |  |  | Same confusion as Huawei. I assume we only discuss RRC\_CONNNECTED remote UE. The procedures are not applicable except RRC-reestablishment. Why we discuss all those procedures together. It is also too early to discuss RRCReestablishment (e.g. path failure case), as this is related to CP primary path discussion. |

## PCell configuration

For Pcell configuration, one proposal is provided in 09375

*Proposal 18 For scenario-1 of multi-path Relay, PCell is always configured on the direct path when configured.*

**Q3: For UEs operating in MP Relay, if the two paths are for different cells, which case(s) is a valid case?**

**Case-1: The cell of direct path is PCell of the UE**

**Case-2: The cell of indirect path is PCell of the UE**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | Case-1 | Case-1 | If we put PCell on direct path, it means Uu interface is only with SCell, which did not happen before, and the problem is how to perform RACH, PUCCH reporting and RLM, which relies on the existence of PCell based on the current spec. |
| Xiaomi | Both | Both | In R17, it’s already supported the PCell is on the indirect path, since it’s the only way.  [Rapp comment] this Q is limited to ‘**For UEs operating in MP Relay**’, R17 is limited to single (indirect) path case.  In addition, direct path can be added to improve thoughput. In this case, it’s not CA between direct and indirect path. It’s more like DC structure. There should be one cell on the direct path acting as PSCell.  The motiviation of PCell on indirect path is to improve the reliability. Remote UE is expected at the cell edge, according to the Uu threshold condition. The indirect path may be more reliable at cell edge. If the associated cell of direct path and indirect path is different, it may be more reliable to put PCell on indirect path.  [Rapp comment] although might be anyway inevitable, still suggest to provide argument besides the DC-modelling / CP P/S-path thing which is a bit controversial at the current stage.. |
| CATT | Both | Case-1 | For scenario-1, in Rel-17, remote UE’s PCell is the serving cell of relay UE. For MP. For the case addition of direct path over indirect path, PCell should be the cell of indirect path. Remote UE should not change the MAC-I in path add/modification procedure. |
| Huawei, HiSilicon | Ask for clarification | Ask for clarification | We would like to better understand the question. In the original proposal 18, when it says PCell is “configured”, does it imply PCell change procedure? Because during other cases like RRC setup/re-establishment/resume, the UE takes the cell/Pcell of the connected Relay UE ( via which the RRC procedure is initated) as PCell, which is not configured by network. |
| vivo | Case-1 | Case-1 | Regarding PUCCH configuration, random access procedure, special deactivation limitations and so on, it is a simplest way to accept PCell in Uu link as the real PCell of remote UE. Otherwise, if we choose PCell of relay UE as PCell of remote UE in multi-path scenarios, remote UE cannot work well in Uu link, e.g. lots of legacy behaviors about PCell should be re-considered. |
| ZTE | Both | See comments | For Scenario 1, if the RRC is established via direct path, the remote UE regard the serving cell of direct path as PCell. On the other hand, if the RRC is initially established via indirect path, the remote UE regard the serving cell of indirect path as PCell. Even if the direct path is added after a while, the original serving cell of indirect path can still be regarded as PCell. It is not necessary to change the PCell due to the addition of direct path.  For Scenario 2, if the UE can only establish the RRC via direct path, the serving cell of direct path should work as the PCell. However, if the UE can also establish the RRC via indirect path which is actually still FFS, the serving cell of indirect path may also work as the PCell similar to Scenario 1. |
| Ericsson | Case-1 | Case-1 | Agree with OPPO. In addition, PCell should be configured on the path where the network is capable of performing RLM, given that that is only possible on the direct path, Case-1 is sufficient. |
| Apple | Both | Case 1 | For Scenario 1, we see no reason to restrict PCell to be only in direct path. That will force a PCell change when adding direct path.  For scenario 2, the direct path is always present. So, it is fine to assume PCell is on direct path. |

## Path Switching

R2 reached the conclusion as follows

Agreements:

Proposal 1-1A (modified): The following cases are to be supported for Scenario 1.

A. The remote UE operating only on the direct path adds the indirect path under the same gNB;

B. The remote UE operating only on the indirect path adds the direct path under the same gNB;

C. The remote UE operating in multi-path releases the indirect path;

D. The remote UE operating in multi-path releases the direct path;

G. The remote UE operating in multi-path changes to a new relay UE for the indirect path while keeping the direct path under the same gNB. FFS if this case would be supported via separate release-and-add (A+C in separate reconfigurations) or a single switch procedure (e.g. similar to i2i service continuity).

Proposal 1-1B (modified): The following case is to be not supported for Scenario 1 as a group mobility scenario.

F. The remote UE configured with multi-path keeps the serving relay UE for the indirect path and the serving cell of the remote UE for the direct path while the serving relay UE changes the serving cell of the relay UE under the same gNB;

Agreement:

The following case can be supported via separate release-and-add for scenario 1 (B+D in separate reconfigurations):

E. The remote UE operating in multi-path changes the direct path to a different cell of the same gNB while using the serving relay UE for the indirect path under the same gNB.

FFS if a single procedure for this case would be supported.

Agreements:

Proposal 1-2A: The following cases are proposed to be supported for Scenario 2.

A. The remote UE configured only on the direct path adds the indirect path under the same gNB;

C. The remote UE configured with multi-path releases the indirect path;

Proposal 1-2B: The following case is proposed to be not supported for Scenario 2.

F. The remote UE configured with multi-path keeps the serving relay UE for the indirect path and the serving cell of the remote UE for the direct path while the serving relay UE changes the serving cell of the relay UE under the same gNB;

Proposal 1-2C: Whether to support the following case can be further discussed for Scenario 2.

B. The remote UE configured only on the indirect path adds the direct path under the same gNB;

D. The remote UE configured with multi-path releases the direct path;

E. The remote UE configured with multi-path changes the serving cell of the remote UE for the direct path while keeping the serving relay UE for the indirect path under the same gNB;

G. The remote UE configured with multi-path changes to a new relay UE for the indirect path while keeping the direct path under the same gNB.

One proposal is provided in 09375

*Proposal 19 For scenario-1 of multi-path Relay, in case of path switching, a RRC\_IDLE/RRC\_INACTIVE Relay UE initiates RRC connection establishment procedure upon the message received from a Remote UE via SL-RLC, not limited to SL-RLC0/1.*

**Q4-1: For R18 MP Relay, for the supported path switching scenario (which scenarios to support is up to the specific discussion on scenarios), when there is an addition of indirect path or a change of indirect path, do you agree to support RRC\_IDLE/RRC\_INACTIVE target relay UE?**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | Yes | Yes | Same as in R17. |
| Xiaomi | Yes | Yes |  |
| CATT | Yes | Yes |  |
| Huawei, HiSilicon | Yes | No | For scenario 2, no need to consider the case relay UE is not in RRC connected, because before network configures relay UE to the remote UE, it needs to know and verify the relation between remote UE and relay UE, which means the relay UE should have been connected to the network already. |
| vivo | Yes | Yes |  |
| ZTE | Yes | Yes |  |
| Ericsson | Yes | Yes | No restriction on RRC state |
| Apple | Yes | Yes |  |

**Q4-2: If Yes to Q4-1, how to trigger the RRC\_IDLE/RRC\_INACTIVE target relay UE to initiate RRC connection establishment procedure?**

**Option-1: Upon the message received from a Remote UE via SL-RLC, not limited to SL-RLC1**

**Option-2: Other (please clarify the solution if this is selected)**

**Option-3: Upon the indication/configuration received from a remote UE, e.g. indication/configuration in *RRCReconfigurationSidelink message***

**Option-4: gNB configures *RRCReconfigurationComplete* message deliverd via indirect path, e.g. configure duplication of SRB1 or change the primary RLC entity of SRB1 to indirect RLC entity.**

**Option-5: During discovery/PC5 unicast establishment for multi-path**

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | 1 | 2 (Up to UE implementation) | For Sce-1: in R17, it is limited to SL-RLC1, yet for MP Relay, since SRB1 may not be configured at indirect path, it does not have to be limited to it.  For Sce-2: Since UE-to-UE link is a blackbox, maybe OK to leave it to UE implementation. |
| Xiaomi | 3 | Up to implementation | If relay UE is in IDLE/INACTIVE, NW can send essential multipath configuration to relay UE via remote UE during MP addition. Remote UE can forward the configuration via *RRCReconfigurationSidelink* message to relay UE. Upon reception of the configuration, relay UE can enter CONNECTED. |
| CATT | 4 or 3 | Up to implementation | Both 4 and 3 can trigger RRC\_IDLE/RRC\_INACTIVE target relay UE to initiate RRC connection establishment procedure. |
| Huawei, HiSilicon | 5 | Up to implementation | For scenario 1, according to what we learn from SA2 discussion, the relay UE needs to advertise it support multi-path via service code in discovery message, so when the remote UE establishes PC5 unicast link with the relay UE, the relay UE already knows the access is for multi-path service, then it should enter connected state.  For scenario 2, if the remote UE want to leverage multi-path, it can inform the relay UE to enter connected state on the non-3GPP interface, the detailed method is left to UE implementation. |
| vivo | 1 | 2 : Up to UE implementation | For scenario 1, in Release 17, it is limited to SL-RLC1, i.e. RRC Reconfiguration Complete message. However, in release 18 multi-path relay, the SRB1 may be configured on direct path and consequently RRC Reconfiguration Complete message may not be transmitted via indirect path, it can not rely on it. The first data via indirect path may be a DRB data or a new PC5 indication message can be introduced and so on. Details are FFS.  For scenario 2, an unspecified inter-UE indication may be a simplest way to trigger relay UE to initial RRC connection establishment procedure and details can be left to UE implementation. |
| ZTE | 4 or 5 | Up to implementation | For the Scenario 1, we think both 4 and 5 may work without introducing additional specification impact if the SRB can be configured as split bearer or indirect bearer.  For Scenario 2, it can be up to UE implementation. |
| Ericsson | 2, FFS | UE implementation | Re-use Rel-17 indication. It should be possible when adding the indirect path, to configure a split SRB for SRB1 and as a result, SL-RLC1 will be configured. |
| Apple | 3 | Up to UE implementation | We think option 4 is unnecessary. There is no need to force SRB1 duplication or reconfigure primary path just for the triggering of IDLE/INACTIVE relay UE case. We can rely on PC5-RRC. |

## RLM/RLF

One proposal is provided in 09375

*Proposal 20 For scenario-1 of multi-path Relay, UE performs RLM on both direct and indirect path.*

When UE operating in MP Relay, which path(s) to perform RLM?

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Scenario-1 | Scenario-2 | Comment |
| OPPO | Uu + PC5 | Uu, and UE-UE link is left to UE implementation | For Scenario-1, it is clear and it is just to follow legacy procedure.  For Scenario-2, the handling of UE-UE link is a blackbox, so the key issue is whether/how to handle if there is some ‘failure’ like event at UE-UE link, yet no need to dig into the need of RLM though. |
| Xiaomi | Both | At least Uu | Although the RLM is performed on both link, the consequence of RLF on either path may be different. Note in legacy, UE would trigger RRC reestablishment if the RLF occurs on the only direct or indirect path. However, in multipath, RLF on one path may not trigger RRC reestablishment, if the path is only responsible for DRB transmission.  For scenario, whether ideal connection could fail can be clarified. |
| CATT | Both direct and indirect path | At least direct path. | For Scenario-1, reuse legacy procedure.  For Scenario-2, RLM for ideal link is up to UE implementation |
| Huawei, HiSilicon | Both | Uu | For scenario 1, the RLM on both paths are possible, but the detailed discussion also relates to the specific cases, e.g. whether the Uu Cell is PCell or not. |
| vivo | Uu + PC5 | Uu only | For scenario 1, legacy mechanisms can be reused.  For scenario 2, there is no need for RLM between two UEs. However, relationship reporting between UEs may be needed, e.g. inter-UE connection available or not available. |
| ZTE | Both | Uu | For scenario 1, we think it is necessary for the multi-path remote UE to perform RLM on both path independently. When RLF is detected on direct/indirect path, it is natural to reuse the legacy fast RLF recovery design, i.e. multi-path remote UE may send the direct/indirect path failure information to gNB via the indirect/direct path. Only if both path are not available or suspended, the remote UE may perform the RRC re-establishment via either direct path or indirect path as legacy UE.  For scenario 2, only the RLM on Uu need to be specified. The RLM for UE-UE connection can be up to implementation. |
| Ericsson | Uu | Uu | Firstly, we think there should be a differentiation between RLM and RLF. RLM is the procedure for link monitoring based on configured reference signals and this is only supported on the direct path. On the PC5 link, there is no RLM procedure i.e., configured reference signals for link monitoring.  RLF is declared based on RLM, on Uu, based on in-sync and out-of-sync indications from monitoring configured reference signals. On the PC5 interface, RLF is declared based on RLC/HARQ DTX/T400 expiry.  As a result, we believe there is no RLM on the indirect path at least on the PC5-link. |
| Apple | Both | At least Uu | It is unclear how do conduct RLM in a non-3GPP link for scenario 2 |

1. xxx.

# Conclusion

We have the following proposals:

[Proposal 1 xxx.](#_Toc116550638)

# Reference

1. xxx