**3GPP TSG-RAN WG2 Meeting #129 R2-24xxxxx**

**Athens, GR, 17th – 21st February 2025**

**Agenda Item: 8.13.3**

**Source: InterDigital**

**Title: Report of [POST128][401][Relay] Control Plane Baseline Solution**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution gives the discussion summary of following post email discussion.

* [Post128][401][Relay] Control plane baseline solution (InterDigital)

 Scope: Develop the baseline control plane procedures for connection establishment, and paging/system information forwarding, towards a stage 3 development stage.

 Intended outcome: Report to RAN2#129

 Deadline: Long

## Contact information

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# 2 Discussion

## 2.1 Connection Establishment

For the control plane baseline solution (i.e., approach 1), the figure and description under P1 of R2-2410006 serves as the baseline connection establishment procedure. These are repeated here for illustration. A number of FFSs were identified upon agreement of the baseline procedure. These are discussed in more details.



1. The U2N Remote UE, First Relay UE, Intermediate Relay UE, and Last Relay UE perform discovery procedure, and establish a PC5-RRC connection between each adjacent UE (U2N Remote UE<->First Relay UE, First Relay UE <-> Intermediate Relay UE, Intermediate Relay UE <-> Last Relay UE) using the NR sidelink PC5 unicast link establishment procedure. [FFS whether to support PC5-RRC connection establishment between some adjacent UEs after transmission of the first RRC message in step 2.]
2. The L2 U2N Remote UE sends the first RRC message (i.e., *RRCSetupRequest*) for its connection establishment with gNB via the First Relay UE, using a specified PC5 Relay RLC channel configuration. The first Relay UE sends the *SidelinkUEInformationNR* message to request for the dedicated configurations required to support the multi-hop relay operation for the U2N Remote UE. If the First Relay UE is not in RRC\_CONNECTED, it needs to do its own Uu RRC connection establishment via the Intermediate Relay UE (using similar actions as a U2N Remote UE) upon reception of a message from U2N Remote UE on the specified PC5 Relay RLC channel. The Intermediate Relay UE sends the *SidelinkUEInformationNR* message to request for the dedicated configurations required to support the multi-hop relay operation for the U2N Remote UE. If the Intermediate Relay UE is not in RRC\_CONNECTED, it needs to do its own Uu RRC connection establishment via the Last Relay UE (using similar actions as a U2N Remote UE) upon reception of a message from the First Relay UE on the specified PC5 Relay RLC channel. The Last Relay UE sends the *SidelinkUEInformationNR* message to request for the dedicated configurations required to support the multi-hop relay operation for the U2N Remote UE. If the Last Relay UE is not in RRC\_CONNECTED, it needs to do its own Uu RRC connection establishment upon reception of a message from the Intermediate Relay UE on the specified PC5 Relay RLC channel. In each of the previous sub-steps, if a given relay UE and its parent relay UE both need to enter RRC\_CONNECTED, the given relay UE cannot do so until the parent relay UE has completed its own RRC connection establishment. The Last Relay UE receives SRB0 relaying Uu Relay RLC channel configuration for the Intermediate Relay UE from gNB. The Intermediate Relay UE receives SRB0 relaying Relay RLC channel configuration for the First Relay UE from gNB. The gNB configures SRB0 (for U2N Remote UE) relaying RLC channel to the first Relay UE. The gNB responds with an *RRCSetup* message to U2N Remote UE. The *RRCSetup* message is sent to the U2N Remote UE using SRB0 relaying Last Relay RLC channel over Uu and the specified PC5 Relay RLC channels over each of the PC5 links. [FFS whether the Last Relay UE can send SUI on behalf of all other relay UEs.]
3. The gNB, Last Relay UE, Intermediate Relay UE and First Relay UE perform relaying channel setup procedure over Uu. According to the configuration from the gNB, the First Relay/U2N Remote UE establishes a PC5 Relay RLC channel for relaying of SRB1 towards the U2N Remote UE/First Relay UE over PC5, the Intermediate Relay/First Relay UE establishes a PC5 Relay RLC channel for relaying of SRB1 towards the First Relay UE/Intermediate Relay UE over PC5 and the Last Relay UE/ Intermediate Relay UE establishes a PC5 Relay RLC channel for relaying of SRB1 towards the Intermediate Relay UE/Last Relay UE over PC5. [FFS if each relay UE can establish RLC channel for relaying of SRB1 at the same time as its connection establishment in step 2].
4. The *RRCSetupComplete* message is sent by the U2N Remote UE to the gNB via the First Relay UE, Intermediate Relay UE and the Last Relay UE using SRB1 relaying channels over PC5 and SRB1 relaying channel configured to the Last Relay UE over Uu. Then the U2N Remote UE is RRC\_CONNECTED with the gNB.
5. The L2 U2N Remote UE and gNB establish security following the Uu security mode procedure and the security messages are forwarded through the First Relay UE, Intermediate Relay UE, and Last Relay UE.
6. The gNB sends an *RRCReconfiguration* message to the U2N Remote UE via the Last Relay UE, Intermediate Relay UE, and First Relay UE to setup the end-to-end SRB2/DRBs of the U2N Remote UE. The U2N Remote UE sends an *RRCReconfigurationComplete* message to the gNB via the First Relay UE, Intermediate Relay UE, and Last Relay UE as a response. In addition, the gNB may configure additional Uu Relay RLC channels between the gNB and Last Relay UE, and PC5 Relay RLC channels between each of the Intermediate Relay UE, First Relay UE, and U2N Remote UE for the relaying traffic.

Based on the above procedure, for gNB to control each relay UE by RRC, each relay UE needs to be in RRC connected. As a result, for connection establishment of the remote UE, each relay UE should trigger its own connection establishment. For the last relay UE, Uu connection establishment is performed. However, for the other relay UEs, upon reception of a message on SL-SLB0, they perform connection establishment as though they are acting as a remote UE.

### 2.1.1 Timing of PC5 Connection Establishment

In the baseline figure, PC5 connection establishment is performed between each hop of the multi-hop path prior to transmission of the RRCSetupRequest message by the remote UE. This is the case in Rel17 single hop and was considered the baseline for extension of the connection establishment procedure for multi-hop. During the discussion in [POST127][402][Relay], it was suggested that discovery and connection establishment can be triggered by an intermediate relay UE after reception of the RRCSetupRequest by the remote UE. The following FFS was captured in step 1:

*[FFS whether to support PC5-RRC connection establishment between some adjacent UEs after transmission of the first RRC message in step 2.]*

In essence, step 1 may result in the PC5 connection establishment between the remote UE and the first relay only, and discovery and PC5 connection establishment may be performed upon reception of the RRCSetupRequest from the remote UE.

Question 1.1: Should the option of initiating discovery and PC5 connection establishment between all UEs (except between the remote UE and the first relay) only upon reception of RRCSetupRequest (i.e., during step 2) be supported?

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | No | We fail to get the motivation of this optimization on the coupling of PC5 link establishment and RRCSetupRequest.of remote UE.Multi-hop U2N not only supports CONNECTED remote UE but also supports IDLE/INACTIVE remote UE for SIB/Paging forwarding via PC5 unicast link. Besides, W/O the PC5 discovery/connection between the intermediate/first relay and the last relay, we understand the multi-hop relay link is not available, then what is the point of PC5 connection between the remote UE and the first relay UE?  |
| InterDigital | No | Similar to single hop, the PC5 connections for each of the hops should be established immediately after discovery procedure and without any reliance on Uu signaling/triggers by the remote UE. |
| Huawei, HiSilicon | No | In our understanding of PC5 connection establishment among relay UEs and the remote UE sending RRCSetupRequest to the first relay UE are two independent procedure which will be triggered at different time. We think the remote UE can send the RRCSetupRequest once it has established the PC5 connection with the first relay UE. On the other hand, the PC5 connection establishment among relay UEs will be triggered after the path selection is done by the remote UE. The remote UE can send the path information to the first relay UE during PC5 connection establishment and then hop-by-hop PC5 connection will be established based on the path information between other relay UEs on the path . Therefore, the relay UEs does not need wait for the first RRC message from Remote UE to establish the PC5-RRC connection.  |
| Sharp | No | The Order of connection establishment is up to upper layer. |
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### 2.1.2 SUI Message

In the baseline figure (i.e., step 2), each relay UE sends SUI message to the network to trigger the network to send dedicated configuration at that relay UE for communicating with the remote UE. During the discussion in [POST127][402][Relay], it was suggested that the last relay UE could send SUI message (including path information) to the gNB for requesting the dedicated configuration for each of the relays for operation with the remote UE. This was captured with the following FFS:

[FFS whether the Last Relay UE can send SUI on behalf of all other relay UEs.]

Question 1.2: Should the option of the last relay UE only sending SUI to the network (on behalf of other relay nodes) during connection establishment procedure?

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | No | In the baseline procedure (follow legacy mechanism), each relay UE sends its own SUI and NW provides dedicated configuration based on that. We understand this mechanism works well. The optimized option has big impact on the SUI format and also requires additional PC5 signaling exchange to let the last relay know the “SUI content of other relays”. So this option should not be pursued unless real issue identified. |
| InterDigital | Yes | We are open to considering this if the specification impact can be minimal. For example, each relay can send SUI information as a Uu RRC message encapsulated into a PC5-RRC message to the next relay UE. This would save significant Uu signaling overhead associated with the connection establishment. |
| Huawei, HiSilicon | No | Agree with OPPO that the baseline R17 procedure should be adopted for R19 where each relay UE sends its own SUI and NW provides dedicated configuration based on that. If we think of breaking the legacy mechanism, we need to first answer the following question.How the last relay UE would get the remote UE’s L2 ID?Is the big impact SUI message to contain multiple L2 ID of remote UE is justified?We don’t think there is no need to have any complicated procedures unnecessarily as it will have big impacts to the specifications and should not be pursued further  |
| Sharp | No | If Last relay sends SUI including information for other relay UEs and remote UE, other relay UEs and remote UE need to provide information to the last relay UE hop-by-hop PC5-RRC message. So, it has no effect in reducing PC5-RRC signaling between UEs. Furthermore, an intermediate relay UE needs to process at RRC layer to integrate information of child node(s). It may cause delays. And there may not be effects for reducing data amount sent from the last relay to the gNB. |
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Towards defining the stage 3 baseline procedure, the contents of the SUI message should be discussed.

Question 1.3: If the answer to Q1.2 is Yes, what should be added to the SUI message of the last relay UE (compared to Rel17)?

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| **Companies** | **Comments** |
| InterDigital | Path information can be implicitly included in the SUI message by an ordered list of Uu RRC messages from each subsequent relay UE. |
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Question 1.4: If the answer to Q1.2 is No, what should be added to the SUI message transmitted by each relay UE (compared to Rel17)?

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| **Companies** | **Comments** |
| OPPO | Our current understanding is the R17 SUI format can be reused. No additional information needed. The key difference between R17 single-hop relay and multi-hop relay is how for the network to identify the path information, we understand with the ordered SUI reporting by each of the relay UE, NW can identify the path information already. |
| Huawei, HiSilicon | Reusing the sequential procedure of sending SUI will provide the NW with the path information implicitly. No further additions are needed for R17 SUI message. |
| Sharp | R17 format can be reused to receive RRC reconfiguration for the remote UE. Information to identify number of hops may be helpful. |
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### 2.1.3 SRB1 Relaying RLC Channel Establishment

During the discussion in [POST127][402][Relay], it was suggested that the SRB1 RLC channel establishment of each relay UE (in step 3) can be performed together with the relay UE’s own connection establishment in step 2. The following FFS was captured.

*[FFS if each relay UE can establish RLC channel for relaying of SRB1 at the same time as its connection establishment in step 2].*

In rapporteur’s understanding, each relay UE can initiate establishment of SRB1 upon reception of its own RRCSetup message (as for U2N relay in Rel17). In essence, the split between step 2 and step 3 in stage 2 was to allow re-use of stage 2 description from Rel17 as much as possible.

Question 1.5: Do you agree that a relay UE (intermediate relay UE or last relay UE) can establish the SRB1 relaying RLC channel upon reception of its own RRCSetup message (i.e., without having to wait for child node RRCSetup messages to be received).

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | See comments | We agree to follow R17 as much as possible. In R17, relay UE establish SRB1 relaying RLC channel upon reception of RRC reconfiguration from the network, so we understand it would be clearer to say “relay UE (intermediate relay UE or last relay UE) can establish the SRB1 relaying RLC channel upon reception of SRAP configuration from the network~~its own RRCSetu~~p ~~message~~ (i.e., without having to wait for child node RRCSetup messages to be received).”And no need to specify the time point of establishing RLC channel for SRB1 in stage-2 spec, it should be captured in RRC specification as in R17.  |
| InterDigital | Yes | SRB1 can be established upon reception of SRAP configuration (which comes in RRC setup message). We are also ok with the wording suggested by OPPO. |
| Huawei, HiSilicon | See comment | In general we agree to follow R17 as much as possible where the RLC channel configurations for relaying of SRB1 at relay UEs are configured one by one,  |
| Sharp | Yes |  |
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Assuming rapporteur’s view is the common understanding, rapporteur sees a few ways to address this in stage 3 description:

1. Add a note to step 3 to clarify that each relay UE can establish its SRB1 relaying PC5-RLC channel upon reception of its RRC Setup in step 2
2. Split Step 2 and 3 in the figure into multiple steps, each corresponding to RRC connection establishment of each relay UE
3. Leave the current description as is, with the assumption that the current stage 2 already captures the common understanding of the rapporteur.

Question 1.6: If the answer to Q1.5 is yes, what enhancements which approach should be taken with respect to stage 2 description?

1. **Add a note to step 3 to clarify that each relay UE can establish its SRB1 relaying PC5-RLC channel upon reception of its RRC Setup in step 2**
2. **Split Step 2 and 3 in the figure into multiple steps, each corresponding to RRC connection establishment of each relay UE**
3. **Leave the current description as is, with the assumption that the current stage 2 already captures the common understanding of the rapporteur.**
4. Other

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| **Companies** | **Selected option(s)** | **Comments** |
| OPPO | See comments | Our understanding is current stage-3 spec seems clear already, no need for additional note/clarification on this:5.3.5.15.3 L2 U2N or U2U Remote UE Addition/ModificationThe L2 U2N Relay UE shall:1> if no SRAP entity has been established:2> establish a SRAP entity as specified in TS 38.351 [66];1> for each *sl-L2IdentityRemote* value included in the *sl-RemoteUE-ToAddModList* that is not part of the current UE configuration (L2 U2N Remote UE Addition):2> configure the parameters to SRAP entity in accordance with the *sl-SRAP-ConfigRelay*;2> if SRB1 is included in *sl-MappingToAddModList*, and *sl-EgressRLC-ChannelPC5* is configured:3> release SL-RLC1, if established;3> associate the PC5 Relay RLC channel as indicated by *sl-EgressRLC-ChannelPC5* with SRB1;2> else: (i.e. SRB1 is not included in *sl-MappingToAddModList*, or SRB1 is included in *sl-MappingToAddModList*, but *sl-EgressRLC-ChannelPC5* is not configured)3> if SL-RLC1 is not established:4> apply the default configuration of SL-RLC1 as specified in clause 9.2.4 and associate it with the SRB1; |
| InterDigital | 3 | Stage 2 should be clear already, but fine with going with option 1 and adding a clarification to stage 2. In any event, as indicated by OPPO, this will be clarified in stage 3. |
| Huawei, HiSilicon | See Comments | We also have similar view as OPPO. |
| Sharp | No need | Current spec is already clear but some clarifications are helpful for understanding =>1 may be ok if it’s majority view. |
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### 2.1.4 Other Connection Establishment Details

In rapporteur’s view, current stage 2 discussion and the above questions should cover the differences between Rel17 connection establishment and multi-hop connection establishment to begin stage 3 development by relying on stage 3 of Rel17 as a baseline.

Question 1.7: Are there any other details which require discussion before defining the differences with multihop connection establishment procedure in the RRC specification?

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## 2.2 System Information

In Rel17, a L2 remote UE can obtain system information from its U2N relay UE or directly from the network. In RRC\_CONNECTED, the remote UE uses the legacy Uu RRC signaling to obtain the SI directly from the cell, seeing that the Uu RRC signaling can be forwarded transparently by the relay UE. When the remote UE is in RRC\_IDLE/RRC\_INACTIVE, PC5-RRC is used for the remote UE to request SI from the U2N relay UE (using the RemoteUEInformationSidelink message) and for the U2N relay to provide the SI to the remote UE (using the UuMessageTransferSidelink). The SI request mechanism for the remote UE on PC5-RRC involves:

* The remote UE sends its required SI in RemoteUEInformationSidelink to the U2N relay UE when the remote UE transitions to RRC\_IDLE/RRC\_INACTIVE, or when there is a change in the required SI.
* When the remote UE moves to RRC\_CONNECTED, it sends RemoteUEInformationSidelink to release the required SI at the relay.
* The U2N relay UE will send to a remote UE, any required SI for that remote UE (e.g., when there is a change in such SI)

In RAN2#128, it was agreed that the SI of the remote UE is provided by forwarding over each of the intermediate UEs.

Agreement:

In multi-hop, the U2N Remote UE acquires the SI of the cell of the Last Relay UE, which is forwarded via the Intermediate Relay UE(s). FFS how to perform the forwarding and whether an intermediate relay UE can forward available SI directly (rather than retrieving it from the last relay UE).

*Remote UE*

It should be expected that the Rel17 behavior at the remote UE can be re-used for multi-hop.

Question 2.1: Do you agree that the remote UE in multi-hop (as for Rel17 in single hop):

* + When RRC\_CONNECTED, uses Uu RRC signaling to obtain its system information directly from its connected cell.
	+ When RRC\_IDLE/RRC\_INACTIVE, can request SI from using PC5-RRC signaling (e.g., RemoteUEInformationSidelink message)
	+ When in RRC\_IDLE/RRC\_INACTIVE, receives the required SI from PC5-RRC signaling (e.g., UuMessageTransferSidelink)?

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 2.2: Do you agree that for a remote UE in multi-hop, the same triggers as Rel17 are supported for sending the PC5-RRC message (e.g., RemoteUEInformationSidelink) namely:

* + when there is a change in the required SI while in RRC\_IDLE/RRC\_INACTIVE, or when entering RRC\_IDLE/RRC\_INACTIVE
	+ when it entering RRC\_CONNECTED, a PC5-RRC message (e.g., RemoteUEInformationSidelink) is sent to cancel a previously sent required SI

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 2.3: Are any new triggers at the remote UE needed for sending PC5-RRC message for SI request (e.g., via RemoteUEInformationSidelink)?

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| **Companies** | **Yes or No** | **Details if answer is Yes**  |
| OPPO | No |  |
| InterDigital | No |  |
| Huawei, HiSilicon | No |  |
| Sharp | No |  |
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*Last Relay UE*

Last relay UE behaviour should be similar to U2N relay behaviour in Rel17. In Rel17, the U2N relay sends SI to the remote UE when it detects a change in any of the SI which was flagged as required by the remote UE. In addition, the U2N relay UE can send SIB1 unsolicited to the remote UE.

For multi-hop, it would be natural for the last relay UE to support each of the above triggers for sending SI. In this case, however, the required SI may consist of any SI required by a remote UE or by a child intermediate UE (since we have assumed that an intermediate UE can itself act as a remote UE for its own traffic).

Question 2.4: Do you agree that the last relay UE in multihop can forward SI (e.g., in a UuMessageTransferSidelink) to an intermediate Relay upon (as for Rel17 in single hop):

* acquisition of the SIB(s) requested by a connected child node (intermediate node and/or remote UE)
* reception of updates of any SIBs requested by a remote UE or another a child relay UE, including SIB1
* deciding to perform unsolicited SIB1 forwarding

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes, but | > **reception of updates of any SIBs requested by a remote UE or another a child relay UE, including SIB1**Note that last relay UE receives a request by a connected intermediate relay. Remote UE doesn’t connect with last relay UE in multi-hop relay operation. Forwarding should be operated hop-by-hop. |
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Question 2.5: Are there any new conditions at the last relay UE for forwarding SI to an intermediate Relay and/or remote UE (e.g., in UuMessageTransferSidelink)

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| **Companies** | **Yes or No** | **Details if answer is Yes**  |
| OPPO | No |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | No |  |
| Sharp | No |  |
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*Intermediate Relay UE*

The main details which remain for multi-hop is to determine how the requests and/or SI are forwarded between the last relay UE and the remote UE (i.e., the intermediate relay UE behavior).

Specifically, the FFS from RAN2#128 agreement (see text before Q2.1) relates to how the intermediate relay UE obtains its SI. This may consist of SI requested by a remote UE or SI required by the intermediate relay UE itself (e.g., for its own operation as a remote UE). In following the principle of Rel17, if an intermediate relay UE is in RRC\_CONNECTED, it should be able to receive the SI using dedicated Uu signaling, as it would if it was a remote UE.

Question 2.6: Do you agree that an intermediate relay UE that is RRC\_CONNECTED uses Uu RRC signaling to obtain its system information directly from its connected cell?

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| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes | Intermediate relay UE behavior should be the same as a remote UE in Rel17 when obtaining SI. |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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When the intermediate relay UE is in RRC\_IDLE/RRC\_INACTIVE, it can obtain SI required by it or a child node using the PC5-RRC signaling when out of coverage. However, different from Rel17, the intermediate relay UE may be in-coverage and may already have SI available from cell broadcast.

Question 2.7: When an intermediate relay UE is in RRC\_IDLE/RRC\_INACTIVE, how can it obtain the SI required by it or requested by the remote UE?

1. By requesting SI from the parent relay UE in PC5-RRC (e.g., using RemoteUEInformationSidelink)
2. Directly from the SIB broadcast by the cell on Uu (if in coverage)

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| **Companies** | **a) and/or b)** | **Comments** |
| OPPO | a) | The same behavior for remote UE should be followed since * As discussed in question 2.4, we assume intermediate relay also acts as remote UE, so unified solution should be applied here;
* We have agreed in RAN2 #128 that there is an upper bound of Uu RSRP to operate as an intermediate relay UE, which means the intermediate relay UE is most likely located at cell-edge or OOC.
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| InterDigital | a) and b) | There should be no need to artificially restrict the intermediate relay UE to obtain SI from its parent UE. This would trigger unnecessary signaling to the parent relay when the intermediate relay already has the SI (via broadcast Uu as in legacy) |
| Huawei, HiSilicon | a) | Since the intermediate relay UE will also act as a remote UE the same mechanism should be used. Additionally, agree with Oppo’s 2nd bullet that the intermediate relay UE is most likely located at cell-edge or OOC |
| Sharp | a) |  |
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The triggers for sending an SI request via PC5-RRC for the remote UE should at least be supported by the intermediate relay UE since it can itself behave as a remote UE and should request its own SI. In addition, new triggers specific to an intermediate UE may need to be introduced.

Question 2.8: What triggers the intermediate relay UE to send SI request in PC5-RRC (e.g., in RemoteUEInformationSidelink) to the parent relay (intermediate relay or last relay)?

1. when there is a change in the SI required by the intermediate UE
2. when the intermediate UE enters RRC\_IDLE/RRC\_INACTIVE
3. when the intermediate UE enters RRC\_CONNECTED (to cancel a previously sent SI request)
4. upon reception of new/changed required SI received from a remote UE/child relay UE?
5. change in the ability of the intermediate UE to receive SIB broadcast on Uu (e.g., moving in/out of coverage) to initiate/cancel SI forwarding by the parent relay.
6. Others

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| **Companies** | **Selected options** | **Comments** |
| OPPO | a), b), c), d) | For e), as replied in Q 2.7, an “in coverage intermediate relay UE acquires broadcast SIB on Uu” doesn’t seem a valid scenario to us considering:* We have agreed the Uu RSRP upper bound for acting as intermediate relay UE which means intermediate relay (similar to R17 Remote UE) will be OOC or at cell-edge which cannot perform Uu Tx/Rx directly;
* In R17, the remote UE always relies on the relay UE to acquire SIB, same principle should be followed for the intermediate relay UE;
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| InterDigital | a-e | All are relevant, and e) is needed for cases where the intermediate relay moves out of coverage |
| Huawei, HiSilicon | a), b), c), d) | Option e is not needed |
| Sharp | a), b), c), d), f) | “f) When a PC5-RRC connection with a remote UE/ a child relay UE is released due to some reasons.”Above trigger f) can be included in trigger a) since the intermediate relay UE releases a configuration of a remote UE/ a child relay UE when the PC5-RRC connection is released. |
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Similarly, an intermediate relay UE may trigger transmission of SI to a remote UE (or child intermediate relay UE) based on triggers which are different than those in Rel17. Specifically, the intermediate relay UE in RRC\_CONNECTED may receive SI directly from the network and the triggers would be similar to Rel17 U2N relay. In addition, the intermediate relay UE may trigger forwarding of SI upon reception of SI via PC5-RRC from a parent.

Question 2.9: What triggers the intermediate relay UE to send SI (e.g., in UuMessageTransferSidelink) to a child node?

1. Upon reception of SI received from a parent node (intermediate relay or last relay) containing SI requested by a child node (intermediate relay or remote UE)
2. Upon acquisition (from the network) of SI requested by a child node (intermediate relay or remote UE)
3. Upon receiving updated SIBs from the network which have been requested by a child node (intermediate relay or remote UE)
4. Upon reception of SIB1 received from a parent relay (i.e., this case may correspond to SIB1 update detected by the last relay, or unsolicited SIB1 forwarding by the last relay)
5. Upon receiving updated SIB1 from the network (as in Rel17)
6. Upon unsolicited SIB1 forwarding to a connected child node (intermediate relay UE or remote UE)
7. Others

|  |  |  |
| --- | --- | --- |
| **Companies** | **Selected options** | **Comments** |
| OPPO | a), d), f) b), c), e)for CONNECTED intermediate relay only | As replied above, we understand b), c) and e) (intermediate relay acquires SIB from network directly) only applies to connected intermediate relay UE. |
| InterDigital | a-f (all triggers are relevant and they are a direct extension of Rel17 concepts)  | a) and d) would apply for IDLE/INACTIVE only since for CONNECTED, the intermediate relay would not request SI from the parent over PC5-RRC (as in Rel17 remote UE behavior)b), c), and e) would apply for RRC\_CONNECTED and IDLE/INACTIVE (when intermediate UE is in coverage)f) is relevant to all cases (a relay should always be able to decide to forward the SIB1 it has in an unsolicited way, as in Rel17)   |
| Huawei, HiSilicon | a), d), f) | Similar understanding as OPPO that b), c) and e) only applies to connected intermediate relay UE |
| Sharp | a), b), c), d), e), f)  | If e) means that the intermediate relay UE in RRC\_CONNECTED receives SIB1 through dedicated RRC message, we can agree with option e). But there may be some overlap with option b). If e), f) means the intermediate relay UE receives SIB1 on Uu directly, we don’t support these.  |
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In single-hop (Rel17) forwarding of SI, the relay UE which sends the SI is also the one that acquires it on behalf of a remote UE. Because this UE acquires the SI from the network, it needs to know the specific SIBs that were requested via the requested SIB list.

An intermediate UE may not be involved in the actual SIB acquisition but may instead simply forward the SI request to the parent/last relay. In this case, it may not be necessary for the intermediate relay UE to have knowledge of the SI required by each remote UE. When an SI message arrives from the parent node, however, it would require the message to be forwarded to all child nodes. Alternatively, if an intermediate UE keeps track of the required SIB(s) of each remote UE (or child node), the intermediate UE could forward a message only to the UE which requested it (rather than all UEs).

Question 2.10: What option is preferrable for how the intermediate UE performs SI forwarding when it receives the SI from a parent relay?

1. The intermediate UE forwards the SI message to all child UEs
2. The intermediate UE forwards the SI message only to the child UEs which requested that specific SI (i.e., the intermediate UE keeps track of the required SI for each child node)

|  |  |  |
| --- | --- | --- |
| **Companies** | **a) or b)** | **Comments** |
| OPPO | b) | Same as R17 relay behavior |
| InterDigital | b) |  |
| Huawei, HiSilicon | b) |  |
| Sharp | b) | a) may waste radio resources. |
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*PC5-RRC Messages (e.g., RemoteUEInformationSidelink, UuMessageTransferSidelink)*

To support SI forwarding in Rel17, RemoteUEInformationSidelink from the remote UE to the U2N relay contains the requested SIB list (in Rel18, the requested PosSIB list was added) and the UuMessageTransferSidelink from the U2N relay to the remote UE contains the forwarded SI (SIB1 and other system information).

RemoteUEInformationSidelink-r17-IEs ::= SEQUENCE {

 sl-RequestedSIB-List-r17 SetupRelease { SL-RequestedSIB-List-r17} OPTIONAL, -- Need M

 sl-PagingInfo-RemoteUE-r17 SetupRelease { SL-PagingInfo-RemoteUE-r17} OPTIONAL, -- Need M

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 nonCriticalExtension RemoteUEInformationSidelink-v1800-IEs OPTIONAL

}

UuMessageTransferSidelink-r17-IEs ::= SEQUENCE {

 sl-PagingDelivery-r17 OCTET STRING (CONTAINING PagingRecord) OPTIONAL, -- Need N

 sl-SIB1-Delivery-r17 OCTET STRING (CONTAINING SIB1) OPTIONAL, -- Need N

 sl-SystemInformationDelivery-r17 OCTET STRING (CONTAINING SystemInformation) OPTIONAL, -- Need N

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 nonCriticalExtension UuMessageTransferSidelink-v1800-IEs OPTIONAL

}

In multi-hop, it would seem that at least this information should be present not only in the messages transmitted by the remote UE and last relay, but also in the intermediate relay UE. If this is the case, it would also be beneficial to re-use the same PC5-RRC messages rather than define new ones.

Question 2.11: Do you agree that the PC5-RRC message containing the required SI that is transmitted by the remote UE or by the intermediate relay UE to the parent node contains at least the requested SIB list (as in Rel17)?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 2.12: Do you agree to re-use RemoteUEInformationSidelink as the PC5-RRC message transmitted by the remote UE or by the intermediate relay UE to the parent node (intermediate relay or last relay) to provide the required SI?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes | > **relay) to provide the required SI?**Agree to reuse the message as a request the required SI. |
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Question 2.13: Do you agree that the PC5-RRC message transmitted by the last relay UE or by the intermediate relay UE that provides the SI to a child node contains at least containers with SIB1 and other system information (as in Rel17)?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 2.14: Do you agree to re-use UuMessageTransferSidelink as the PC5-RRC message transmitted by the Last relay or by the intermediate relay UE that provides SI to the child node?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Whether additional information is needed in these messages may depend on specific use cases to be supported. In RAN2#128, the case of an intermediate relay UE serving multiple indirect paths of different remote UEs was discussed.

Agreements:

The following cases are supported for L2 multihop relay:

- One last Relay UE can have two connections with one intermediate Relay UE and one Remote UE (the intermediate Relay UE and Remote UE are physically different UE).

- Two physically different Remote UE(s) can have each indirect path via the same intermediate Relay UE and the same last Relay UE.

FFS if the last relay UE can use the same L2ID for both of the connections in either case.

Cases with two indirect paths to the gNB for the same remote UE are not supported.

An Intermediate Relay UE can serve multiple multi-hop indirect paths of different Remote UEs.

If the intermediate Relay UE also is acting as a Remote UE, it cannot support different indirect paths to the gNB with same/different last/U2N/parent intermediate Relay UE(s) based on different PC5 unicast links.

In rapporteur’s understanding, the intermediate relay in question is common between two different paths which serve two different remote UEs. Since the two remote UEs may eventually be connected (via these multiple multi-hop indirect paths) to different cells, each of these cells may have different SIB contents for the same SIBx. However, the remote UE should use the SI of its associated cell only. To ensure this, either the SI request on PC5 by a UE should include the cell ID so that the relay UE knows which cell’s SI to provide to that remote UE, or a requesting UE could receive the same SIB from different cells, and only use the SIB associated with the served cell.

Other information which may be considered useful is the local ID of the remote UE requesting SI. For instance, if an intermediate relay UE receives request from two different remote UEs for a list of SI, the last relay UE which processes the requests may need to know which SI corresponds to which remote UE in order to provide the SI into different messages (e.g., octet strings) – one corresponding to each remote UE. When a remote UE requests new SI, the last relay UE would need to know to which remote UE message to add the requested SI. It would also need to know which previous remote UE SI list the current list is replacing.

Question 2.15: Which of the following information should be added to the PC5-RRC messages for SI request (e.g. RemoteUEInformationSidelink) and/or SI forwarding (UuMessageTransferSidelink) compared to Rel17?

1. The cell ID of the cell corresponding to the requested SI or forwarded SI
2. An identity of the UE (e.g., local ID) requesting the SI or for which the SI is being forwarded
3. Other?

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| --- | --- | --- |
| **Companies** | **Selected option(s)** | **Comments** |
| OPPO | none | We fail to understand the motivation of option a) and b):* For Option a), it is not a valid scenario: the IDLE/INACTIVE intermediate relay UE acts as remote UE since it requires SI/Paging forwarding by the last relay. Which means the multi-path topology has already been confirmed as not supported according to the following agreement

If the intermediate Relay UE also is acting as a Remote UE, it cannot support different indirect paths to the gNB with same/different last/U2N/parent intermediate Relay UE(s) based on different PC5 unicast links.* For Option b), the motivation is not valid since the SI list/SI request list are not remote specific, i.e., there is no per-remote UE “octet strings” and “remote UE message”.
 |
| InterDigital | a) | We think a) is necessary to support the case where “An Intermediate Relay UE can serve multiple multi-hop indirect paths of different Remote UEs.” The case “if the intermediate relay UE is acting as a remote UE” is one subcase of multiple multi-hop indirect paths of different remote UEs, and for this specific case, we restrict only a single path to the network. But for the other cases, different remote UEs should be able to access SI of different cells, so the requested cell information is needed.For b) we think knowledge of that is not needed and the intermediate relay can forward SI to the next hop without specific knowledge of which UE is the intended one.  |
| Huawei, HiSilicon | none | Only tree like topologies will be supported in R19 and it was agreed that no cross topologies will be supported in R19.Hence no additional info is needed compared to R17 |
| Sharp | Comment | We don’t understand the issue and the motivation of option a) and b).If an intermediate relay UE serves connectivity for two remote UEs, the two remote UE should indirectly connect to the same cell. |
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## 2.3 Paging

Paging in Rel17 works in a similar way to system information in that the remote UE sends some information to the relay UE that is required by the relay UE to perform monitoring by the relay UE on behalf of the remote UE. In this case, the information consists of the paging information (paging ID and paging cycle). If the relay UE receives paging for the attached remote UE, the relay UE sends a paging record to the remote UE. Similar to system information, it would be expected that the remote UE and last relay UE behaviour should mimic Rel17.

*Remote UE*

Questions related to remote UE behavior in 3.1-3.3 are similar to those for system information.

Question 3.1: Do you agree that the remote UE in multi-hop (as for Rel17 in single hop):

* + When RRC\_IDLE/RRC\_INACTIVE, can request to receive paging by sending its paging information using PC5-RRC signaling (e.g., RemoteUEInformationSidelink message)
	+ When in RRC\_IDLE/RRC\_INACTIVE, can receive paging record from PC5-RRC signaling (e.g., UuMessageTransferSidelink)?

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| --- | --- | --- |
|  **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 3.2: Do you agree that for a remote UE in multi-hop, the same triggers as Rel17 are supported for sending the PC5-RRC message (e.g., RemoteUEInformationSidelink) namely:

* + when there is a change in the paging information while in IDLE/INACTIVE, or when entering RRC\_IDLE/RRC\_INACTIVE
	+ when it entering RRC\_CONNECTED, a PC5-RRC message (e.g., RemoteUEInformationSidelink) is sent to release the paging information.

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| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 3.3: Are any new triggers at the remote UE needed for sending PC5-RRC message for paging identity information (e.g., via RemoteUEInformationSidelink)?

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| --- | --- | --- |
| **Companies** | **Yes or No** | **Details if answer is Yes**  |
| OPPO | No |  |
| InterDigital | No |  |
| Huawei, HiSilicon | No |  |
| Sharp | No |  |
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*Last Relay UE*

Questions related to last relay UE behavior in 3.4-3.5 are similar to those for system information.

Question 3.4: Do you agree that the last relay UE in multihop can forward paging to an intermediate Relay upon receiving paging message related to a multihop remote UE, or intermediate relay UE (similar to Rel17 in single hop):

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| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 3.5: Are there any new conditions at the last relay UE for sending paging message to an intermediate relay and/or remote UE (e.g., in UuMessageTransferSidelink)

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| --- | --- | --- |
| **Companies** | **Yes or No** | **Details if answer is Yes**  |
| OPPO | No |  |
| InterDigital | No |  |
| Huawei, HiSilicon | No |  |
| Sharp | No |  |
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*Intermediate Relay UE*

Questions related to last relay UE behavior in 3.6-3.10 are similar to those for system information.

Question 3.6: Do you agree that an intermediate relay UE that is RRC\_CONNECTED disables paging reception by the parent relay UE?

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| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| OPPO | See comments | For clarification, does the “disables paging reception by the parent relay UE” mean release paging related information? |
| InterDigital | Yes | This is as in Rel17. |
| Huawei, HiSilicon | Yes | It disables paging for itself only. Any remote UEs in IDLE/INACTIVE and connected to this intermediate relay UE will continue to receive paging via this intermediate relay UE. |
| Sharp | Yes with clarification | We want to clarify whether the paging related information which is disabled means paging related information of a remote UE/ a child relay UE or the intermediate relay UE or both. If the information is related to paging for the intermediate relay UE (which is also acting as a remote UE), the intermediate relay UE should send information to release paging information as with Rel-17 behaviour. For the paging information of the remote UE, the intermediate relay UE can receive paging information for the remote UE via dedicated RRC message. And an RRC message is forwarded at SRAP layer of a last relay UE (without reaching the RRC layer). Therefore, we agree that the intermediate relay UE that is RRC\_CONNECTED releases paging related information (for both of the remote UE and the intermediate relay UE). |
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Question 3.7: When an intermediate relay UE is in RRC\_IDLE/RRC\_INACTIVE, how can it obtain paging?

1. By requesting paging to be monitored by the parent relay UE (e.g., using RemoteUEInformationSidelink)
2. Directly from paging monitoring on Uu (if in coverage)

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| --- | --- | --- |
| **Companies** | **a) and/or b)** | **Comments** |
| OPPO | a) | Same as SIB case, we should follow the same behavior as remote UE |
| InterDigital | a) and b) | As in previous question for SIB, we don’t see any reason to restrict legacy behavior for a UE in coverage (this would be a rather strange limitation). |
| Huawei, HiSilicon | a) | Similar to R17 mechanism |
| Sharp | a) |  |
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Question 3.8: What triggers the intermediate relay UE to request paging monitoring by the parent relay (intermediate relay or last relay) in PC5-RRC (e.g., in RemoteUEInformationSidelink)?

1. when there is a change in the paging information of the intermediate UE
2. when the intermediate UE enters RRC\_IDLE/RRC\_INACTIVE
3. when the intermediate UE enters RRC\_CONNECTED (to cancel paging monitoring request)
4. upon reception of paging monitoring request from a remote UE/child relay UE?
5. change in the ability of the intermediate UE to monitor paging on Uu (e.g., moving in/out of coverage) to initiate/cancel paging monitoring by the parent relay.
6. Others

|  |  |  |
| --- | --- | --- |
| **Companies** | **Selected options** | **Comments** |
| OPPO | a), b), c), d) |  |
| InterDigital | All a-e |  |
| Huawei, HiSilicon | a), b), c), d) |  |
| Sharp | a), b), c), d), f) | “f) When a PC5-RRC connection with a remote UE/ a child relay UE is released due to some reasons.”Above trigger f) can be included in trigger a) since the intermediate relay UE releases a configuration of a remote UE/ a child relay UE when the PC5-RRC connection is released. |
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Question 3.9: What triggers the intermediate relay UE to send paging message (e.g., in UuMessageTransferSidelink) to a child node?

1. Upon reception of paging message received from a parent node (intermediate relay or last relay) that is intended for a child node (intermediate relay or remote UE)
2. Upon acquisition (from the network) of paging message that is for a child node (intermediate relay or remote UE)
3. Others

|  |  |  |
| --- | --- | --- |
| **Companies** | **Selected options** | **Comments** |
| OPPO | a) |  |
| InterDigital | a) and b) |  |
| Huawei, HiSilicon | a) |  |
| Sharp | a), b) with comment | For b), if “Upon acquisition (from the network)” means that “Upon receiving dedicated RRC message from the network for delivering L2 U2N Remote UE paging” used in R17, we agree with option b).  |
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Question 3.10: What option is preferrable for how the intermediate UE performs paging forwarding when it receives a paging message from a parent relay?

1. The intermediate UE forwards the paging message to all child UEs
2. The intermediate UE forwards the paging message only to the remote UE/intermediate UE being paged or the intermediate UE serving a UE being paged.

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| --- | --- | --- |
| **Companies** | **a) or b)** | **Comments** |
| OPPO | b) |  |
| InterDigital | b) |  |
| Huawei, HiSilicon | b) |  |
| Sharp | b) |  |
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*PC5-RRC Messages (e.g., RemoteUEInformationSidelink, UuMessageTransferSidelink)*

To support paging monitoring in Rel17, RemoteUEInformationSidelink from the remote UE to the U2N relay contains the paging information (UE paging ID and paging cycle) and the UuMessageTransferSidelink from the U2N relay to the remote UE contains the paging record.

RemoteUEInformationSidelink-r17-IEs ::= SEQUENCE {

 sl-RequestedSIB-List-r17 SetupRelease { SL-RequestedSIB-List-r17} OPTIONAL, -- Need M

 sl-PagingInfo-RemoteUE-r17 SetupRelease { SL-PagingInfo-RemoteUE-r17} OPTIONAL, -- Need M

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 nonCriticalExtension RemoteUEInformationSidelink-v1800-IEs OPTIONAL

}

UuMessageTransferSidelink-r17-IEs ::= SEQUENCE {

 sl-PagingDelivery-r17 OCTET STRING (CONTAINING PagingRecord) OPTIONAL, -- Need N

 sl-SIB1-Delivery-r17 OCTET STRING (CONTAINING SIB1) OPTIONAL, -- Need N

 sl-SystemInformationDelivery-r17 OCTET STRING (CONTAINING SystemInformation) OPTIONAL, -- Need N

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 nonCriticalExtension UuMessageTransferSidelink-v1800-IEs OPTIONAL

}

Questions related to last relay UE behavior in 3.11-3.14 are similar to those for system information.

Question 3.11: Do you agree that the PC5-RRC message containing the paging message that is transmitted by the remote UE or by the intermediate relay UE to the parent node contains at least paging information (paging ID and paging cycle) of the remote UE and any serving (parent) intermediate relay UEs?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes | The paging information transmitted by the intermediate relay UE may be a list of paging information of all the child UEs and its own info. |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes | It will contain the list of paging information of all the child UEs connected to it and its own info. |
| Sharp | Yes |  |
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Question 3.12: Do you agree to re-use RemoteUEInformationSidelink as the PC5-RRC message transmitted by the remote UE or by the intermediate relay UE to the parent node (intermediate relay or last relay) to provide the paging record?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 3.13: Do you agree that the PC5-RRC message transmitted by the last relay UE or by the intermediate relay UE contains at least one or multiple paging record(s) associated with intermediate relay UE(s) and/or remote UE(s)?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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Question 3.14: Do you agree to re-use UuMessageTransferSidelink as the PC5-RRC message transmitted by the Last relay or by the intermediate relay UE that provides SI to the child node?

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| --- | --- | --- |
| **Companies** | **Yes or no** | **Comments** |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Sharp | Yes |  |
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For paging request (similar to system information), when a remote UE changes its paging information, the last relay UE would need to link the new paging information to the old information. It may therefore need to know from which remote UE the new paging information is originating from. In addition, if an intermediate UE is allowed to receive paging directly from Uu when in coverage, the remote UE may need to know which cell or relay UE sent the paging message.

Question 3.15: Which of the following information should be added to the PC5-RRC messages for paging monitoring request (e.g. RemoteUEInformationSidelink) and/or paging message transfer (UuMessageTransferSidelink) compared to Rel17?

1. The cell ID of the cell corresponding to where the paging was received
2. An identity of the UE (e.g., local ID) associated with the paging information/paging message
3. Other?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Selected option(s)** | **Comments** |
| OPPO | None | Same as our reply for Q2.15, the motivation is not valid to us. |
| InterDigital | a)  | Same as reply for Q2.15. We should avoid restrictions that change legacy Uu behavior. |
| Huawei, HiSilicon | None |  |
| Sharp | None | The intermediate relay UE and last relay UE can understand to which neighbor node the current paging message needs to be sent. And the message should be forwarded hop-by-hop. |
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4 Conclusion

This contribution makes the following proposals:

TBD

# 5 References

1. R2-2410006 Report of [POST127][402][Relay] Multi-hop relay control plane (InterDigital)
2. RAN2#128 Chairman Notes