**3GPP TSG-RAN WG2 Meeting #111 electronic *R2-20nnnnn***

**Online, August 17th - 28th, 2020**

Agenda Item: 8.7.3

Source: MediaTek Inc. (Rapporteur)

**Title: [AT111-e][605][Relay] L2 Relay Mechanism (MediaTek)**

Document for: Discussion and decision

# Introduction

This document is to kick off the following email discussion:

* [AT111-e][605][Relay] L2 relay mechanism (MediaTek)

      Scope: Discuss and document the proposed L2 relay design(s), focussing on general mechanisms of L2 architecture based sidelink relaying including protocol stacks and high level description of required UP/CP functionalities.

      Intended outcome: Summary with potential agreeable TP

      Deadline:  Monday 2020-08-24 1200 UTC

**Scope highlight:**

This email discussion covers the L2 relay design(s) based on the relevant submitted tdocs to RAN2#111e on NR Sidelink Relay, focussing on general mechanisms of L2 architecture based sidelink relaying including:

* Protocol stack
* High level description of required UP/CP functionalities

This document will not cover the following aspects of L2 architecture based sidelink relaying:

* Detailed aspects of Relay Selection/Reselection
* Detailed procedure Relay Discovery
* Detailed procedure of connection establishment
* Detailed procedure of service continuity and path switch

# Background

The L2 based FeD2D architecture was studied at Rel-14 for LTE. The overall protocol stack and its high level functionalities can act as the reference to L2 based NR sidelink relay architecture.

The example protocol stacks for the user plane and control plane of NR L2 UE-to-Network Relay architecture are described in Figure 1 and Figure 2, which assume an adaptation layer over PC5 for relaying.

In case of L2 based SL Relay, relaying is performed above RLC sublayer via Relay UE for both CP and UP between Remote UE and network. Uu SDAP/PDCP and RRC are terminated between Remote UE and gNB, while RLC, MAC and PHY are terminated in each link (i.e. the link between Remote UE and UE-to-Network Relay UE and the link between UE-to-Network Relay UE and the gNB). Remote UE connected to 5GC via layer 2 UE-to-network relay, establishes its own PDU sessions/DRBs to support the user plane data transmission[1][2][3][4].



Figure 1: User plane stack for L2 UE-to-Network Relay



Figure 2: Control plane stack for L2 UE-to-Network Relay

An adaptation layer over RLC layer exists over Uu interface between Relay UE and gNB for UE-to-Network Relay. The adaptation layer over RLC layer can exists over PC5 between Relay UE and Remote UE and the details is up to the discussion at the next section.

For L2 UE-to-UE Relay architecture, the protocol stacks are similar like L2 UE-to-Network Relay other than the fact that the termination points are two Remote UEs. The example protocol stacks for the user plane and control plane of L2 UE-to-UE Relay architecture are described in Figure 3 and Figure 4 [2][6], which assume an adaptation layer over both PC5 links for relaying. The similar principle of L2 based UE-to-Network Sidelink Relay applies to L2 UE-to-UE sidelink Relay.



Figure 3: User plane stack for L2 UE-to-UE Relay



Figure 4: Control plane stack for L2 UE-to-UE Relay

# Issue list

## Protocol stack for L2 UE-to-Network Relay

**Discussion on Adaptation layer on Uu (between Relay UE and gNB)**

There are multiple documents submitted to RAN2#111e discussing the basic protocol stack for L2 UE-to-Network Relay and L2 UE-to-UE Relay. The majority view is that the adaptation layer should be put over RLC sublayer for both CP and UP between Remote UE and network. It is necessary for RAN2 to confirm this aspect in order to capture the protocol stack figures into the TR for L2 UE-to-NW relay.

**Question 1a: Do you agree that the adaptation layer is put over RLC sublayer for both CP and UP between Remote UE and network for L2 UE-to-NW relay? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes/No  (Yes for over RLC, No for remote UE) | We agree that adaptation layer is over RLC for both CP and UP. However, the question seems to emphasize adaptation layer is needed for both remote UE and NW. Then, we don’t agree that adaptation layer is needed *for remote UE* which is illustrated in Figure 1-4. In our understanding, adaptation layer is just needed between relay UE and gNB because it is intended for remote UE identification and bearer mapping. And it is enough to have adaptation layer over Uu RLC to support mapping between sidelink bearer and Uu bearer.  Please note that SA2 had specified the below UP and CP protocol stack with adaptation layer only over Uu RLC in Annex A of TR 23.752. We think it is sufficient for L2 relay and can be simply adopted by RAN2:        **Update in v13:**  After rapporteur clarified that this question is only related to Adaptation layer on Uu (between Relay UE and gNB), we are fine with Question 1. Our preference is still the above two ones we copied from SA2 TR 23.752. |
| OPPO | Yes | For the hop between relay and network, we assume it is common view.  For the hop between remote and relay (Not sure if rapp would like to use Q1d to address that, or it is also reflected in this Q since it is asked for “**the adaptation layer … between Remote UE and network**”), the existence of adaptation layer would be helpful considering the requirement from the SID that “NOTE 3: Forward compatibility for multi-hop relay support in a future release needs to be taken into account”. |
| Xiaomi | Yes with coments | I understand in this question the adaptation layer is only located in relay and gNB. the necessity of adaptation layer in remote UE is discussed in following questions. |
| Ericsson (Tony) | Yes |  |
| Huawei | Yes | It is pretty clear from SA2 TR and LTE design, we have the adaptation layer above RLC between relay UE and NW. |
| CATT | Yes | It is a common belief that the adaption layer should be in the above of RLC between relay UE and gNB for L2 N2W relay. |
| Apple | Yes |  |
| Sony | Yes |  |
| ZTE | Yes | The question is not clear, whether it addresses only the adaptation layer between relay UE and NW, or also addresses the adaptation layer between remote UE and relay UE as well. It is common sense that the adaption layer is needed between relay UE and NW for identifying remote UE and corresponding DRB. As to the adaptation layer between remote UE and relay UE, it may be beneficial for the identification of normal SL services and relayed services and unified protocol stack with UE-to-UE relay. |
| Convida | Yes | Our understanding of this question is straightforward, and that if there should be an adaptation layer over RLC for both CP and UP between the remote UE and the base station and the answer is yes because at the minimum, the U2N relay should have an adaptation layer in support of remote UE identification and bearer mapping which will be needed in support of QoS and even security for relaying functionality. This question is not about whether or not the remote UE should have an adaptation layer. |
| Interdigital | Yes |  |
| Intel | Yes | We have the same comment as Xiaomi |
| Futurewei | Yes |  |
| Lenovo&MM | Yes for ‘above RLC layer’ | Common understanding is that the adaptation layer is above RLC layer in U2N relay and gNB side. It seems unnecessary for the remote UE to have this new layer. |
| Fujitsu | Yes |  |
| Samsung | Yes | The question is a bit confusing and we assume it refers to the link between the relay and the network (the Uu link), in which case SA2 have already made this assumption. This being said, perhaps RAN should make this decision, and we are ok with adaptation layer above RLC on the Uu link, but no Adaptation layer on the PC5 link. |
| Nokia | Yes | For the hop between Relay and the Network it seems ok. But the purpose of adaptation layer between Remote UE and the Network (even considering the multi-hop scenario) is not clear. It may be needed, if in the multi-hop case, the remote UE acts as the Relay UE in the first hop and the transmission is intended towards the gNB over the Uu from the last hop Relay UE. But it needs to be discussed whether UE-UE Relays require an adaptation layer. |
| vivo | Adaptation yes but not in remote UE | From our point of view, adaptation layer is not needed in the remote UE. Adaptation layer is only located between relay UE and the network to perform bearer aggregation and potential routing function. But there is no need for bearer aggregation and routing in the last/access hop, i.e. PC5 link between remote UE and relay UE.  Hence we think that SA2 and the above QC proposed L2 architecture is enough for L2 UE-to-Network relay. |
| LG | Yes | We agree that the adaptation layer is put over RLC sublayer for both CP and UP layers.  Considering the consistency of the UE-to-UE relay and the future extension for the multi-hop relay, we think that the adaptation layer should be allowed between remote UE and relay UE for the UE-to-NW relay. |
| Fraunhofer | Yes |  |

**The placement of protocol layer on Uu and PC5 for relaying**

According to the documents submitted to RAN2#111e discussing the placement of the protocol layers for L2 Relaying, the majority view is that in case of L2 based SL Relay, Uu SDAP/PDCP and RRC are terminated between Remote UE and gNB, while RLC, MAC and PHY are terminated in each link (i.e. the link between Remote UE and UE-to-Network Relay UE and the link between UE-to-Network Relay UE and the gNB). It is proposed for RAN2 to confirm this aspect in order to capture the protocol stack figures into the TR for L2 UE-to-NW relay.

**Question 1b: Do you agree that in case of L2 based UE-to-NW Relay, Uu SDAP/PDCP and RRC are terminated between Remote UE and gNB, while RLC, MAC and PHY are terminated in each link? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes | As we comment in Q1a, we think the UP/CP protocol stacks specified by SA2 in TR 23.752 is sufficient for L2 relay and can be simply adopted by RAN2. |
| OPPO | Yes |  |
| Xiaomi | Yes | The adaptation layer is also terminated in each link. |
| Ericsson (Tony) | Yes |  |
| Huawei | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Sony | Yes |  |
| ZTE | Yes |  |
| Convida | Yes |  |
| Interdigital | Yes |  |
| Intel | Yes |  |
| Futurewei | Yes |  |
| Lenovo&MM | Yes |  |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes |  |
| vivo | Yes |  |
| LG | Yes |  |
| Fraunhofer | Yes |  |

**Establishment of Remote UE PDU sessions/DRBs**

According to the documents submitted to RAN2#111e discussing the basic protocol stack for L2 Relaying, there is a discussion on the PDU session/DRB establishment for Remote UE, the general view is to let the Remote UE to establish its own PDU sessions/DRBs with the network before user plane data transmission.This should be a general aspect for L2 relaying operation and then RAN2 needs to confirm it for L2 UE-to-NW relay.

**Question 1c: Do you agree that in case of L2 based SL Relay, Remote UE needs to establish its own PDU sessions/DRBs with the network before user plane data transmission? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes |  |
| OPPO | Yes | There seems no alternative to allow the remote UE to send UP data before CP established.. |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Yes but | We think the question is not crystal clear. We agree in principle that the remote UE needs to establish its own PDU session/DRBs (i.e., that is PC5+Uu), but the establishment of the PC5-RRC and the Uu SRB can be decoupled (i.e., remote UE establish the PC5-RRC and exchange some configuration with the relay UE and then the relay UE establish an SRB with the network, is needed to transit to CONNECTED).  Maybe good to address also this aspect related to the link establishment. |
| Huawei | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Sony | Yes |  |
| ZTE | Yes |  |
| Convida | Yes |  |
| Interdigital | Yes |  |
| Intel | Yes | We understand that the PDU session may be established if the Remote UE was previously connected over Uu; if a given PDU session is not established already and the Remote UE is OOC, it should be possible to establish it using relaying. |
| Futurewei | Yes |  |
| Lenovo&MM | Yes |  |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes |  |
| vivo | Yes | The procedures of the remote UE may have the following order:   * Firstly, establish PC5 RRC with the relay UE; * Secondly, establish Uu RRC with the network via the relay UE; * Thirdly, establish its own PDU session(s) and DRB(s);   At last, perform service data transmission. |
| LG | Yes |  |
| Fraunhofer | Yes |  |

**Discussion on Adaptation layer on PC5 (between Relay UE and Remote UE)**

Regarding the support of adaptation layer over PC5, there are diverse views in the documents submitted to RAN2#111e. Some companies see the benefits. Some companies see that it is not essential. The benefits described in the documents mainly include the following [2][3][8][23][42]:

* many-to-one mapping between end-to-end Remote UE Radio bearer and PC5 RLC channel
* The forward compatibility support

In [5] and [10], it is suggested to refer to IAB BAP specified at Rel-16 to design the adaptation layer. In [5], it is suggested to introduce both one-to-one mapping and many-to-one mapping for bearer mapping with reference to IAB BAP specified at Rel-16 and it is proposed to enable both one-to-one mapping and many-to-one mapping for Remote UE RBs to PC5 RLC channel mapping, as supported in the backhaul link between Relay UE and gNB. In [16], it is proposed that multiple Uu relaying backhaul bearers may be used to carry traffic of different QoS classes, for one or multiple remote UEs when relay UE forwards remote UE’s traffic. In [16], it is also proposed that the mapping of the remote UE’s Uu DRB to PC5 RLC channel could be one-to-one or many-to-one mapping.

It should be noted that, if many-to-one mapping is considered between Remote UE RBs and PC5 RLC channel, the placement of adaptation layer over PC5 interface is the precondition, since a protocol layer is needed at PC5 to indicate the exact end-to-end Uu DRB of the data packets that come from a particular Remote UE or going to a particular Remote UE.

With regard to the need of adaptation layer over PC5 for L2 UE-to-Network Relay, RAN2 needs to confirm this in order to describe the protocol stack for L2 UE-to-Network relaying in the TR.

**Question 1d: Which option do you prefer with regard to the need of adaptation layer over PC5 for L2 UE-to-Network Relay? Please give your explanation for your choice:**

**Option1: The adaptation layer is needed over PC5**

**Option2: The adaptation layer is optional needed over PC5**

**Option3: The adaptation layer is not needed over PC5**

**Option4: The adaptation layer is needed over Uu RLC of relay and gNB (as specified in Annex A of TR 23.752)**

**Option 5: The adaptation layer is NOT needed at remote UE, but the adaptation layer is needed between relay UE(s) and gNB (for multi-hop compatibility, adaptation layer is also needed between relay UEs over PC5)**

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| MediaTek | Yes | We support the option to put adaptation layer over PC5 for L2 UE-to-Network Relay with the following consideration (1) It offers the flexibility for mapping over PC5 (i.e. many-to-one mapping) between Remote UE and Relay UE. If not the relay implementation will be complicated with the supported remote UE going up (2)Alignment with UE-to-UE protocol stack |
| Qualcomm | Option 4 | We don’t understand why many-to-1 mapping is needed for PC5. Is it because the number of PC5 RLC channel may not be enough or multi-hop only?   * If it is for not enough number of PC5 RLC channel, we don’t think it is an easy conclusion we can make it now. The similar issue was discussed in IAB for a long time. Thus, we do not agree with this argument. The companies raising issue, please provide a qquantitative analysis why current PC5 RLC channel number is not enough based on SA1 requirement of sidelink relay, and we do think it needs first online discussion. * If it is for multi-hop, note that remote UE is assumed to be connected to only one Relay UE via single-hop in Rel-17, and, does not need to support any multiplexing on the PC5 LCHs.   As we commented in Q1a, we think the UP/CP protocol stacks specified by SA2 in TR 23.752 is sufficient for L2 relay and can be simply adopted by RAN2.  **Update in v13:**  After clarification from rapporteur, our preference is 3)+4) or 5), i.e. two ones we copied in Q1a from SA2 TR 23.752. |
| OPPO | 1 | For the necessity of adaptation layer over PC5:   1. If there is only Uu-traffic (network as termination point) from remote UE, the motivation to allow many-to-one mapping is not that strong, since the number of Uu-DRB per UE is limited to 16 (if without PDCP duplication), while the number of PC5 LCH is also limited to 16, so there is no much need for the many-to-one mapping. However, in order to carry both Uu-traffic (network as termination point) and PC5-traffic (relay as termination point) from remote UE, if one does not allow adaptation layer @ PC5 hop, the LCID space for PC5 has to be extended.   Furthermore, if considering the support of multi-hop relay in the future, as indicated in the SID, it would be more future proof, i.e., considering the remote-UE in 1-hop relay could be the relay-UE in 2-hop rely, and at that time, the adaptation layer would be still needed for the remote-UE of the 1-hop relay, and furthermore, the LCID space extension is also needed, considering the Uu-traffic for the remote-UE of 2-hop relay. |
| Xiaomi | Option 3 | There is only one destination, i.e. gNB, in the U2N relay. We don’t think many to one mapping on PC5 is needed for U2N relay. |
| Ericsson (Tony) | Option1 | We are okay to have the adaptation layer on the relay UE and remote UE. But maybe the question is not crystal clear about this aspect.  From our understanding, the main benefit will be to achieve a unified protocol option for U2U and U2N. The mapping relations comprise two kinds of mapping  Mapping 1: Remote UE RB and PC5 RLC/ RB. This mapping is sufficient to be 1 to 1.  Mapping 2: PC5 RLC/RB and Uu RLC/RB. This mapping can be M to one or one to one.  The adaptation layer at the remote UE is responsible for Mapping 1. However, the adaptation layer is not mandatory in case there is only one to one mapping.  The adaptation layer at the relay UE is responsible for Mapping 2. |
| Huawei | Option 5  (i.e. covers option 3 and/or 4 with multi-hop compatibility) | We prefer option 3 but with more clarification as option 5 to address other companies’ concern.   1. Bearer mapping N:1 is not essential between remote UE and relay UE, as commented by other companies. For the LCID occupation issue, we assume Uu-traffic and PC5-traffic from remote UE will use separate L2 ID/PC5 RRC connection. Then, even with only 1:1 mapping, the LCID space is sufficient, since LCID space is per PC5 RRC connection rather than per UE. 2. For multi-hop compatibility, the adaptation is not needed in the last hop (between remote UE1 and relay UE2), but needed in those hops closed to gNB (between relay UE2 and UE3 and gNB). In this assumption, the adaptation header for UL can be added by relay UE2 to identify the ID of remote UE1 and its bearer related ID.   **Remote UE1<->relay UE2<->relay UE3<->gNB**   1. For the unified design with U2U, we think “using adaptation layer above RLC” is already the unified design. We don’t have to design all the details same as U2U. |
| To be honest, both two approaches with/without adaptation layer in SL should work well. We see no critical issue on each option. R2 can select either with or without adaptation layer at SL to proceed the SI discussion. |
| CATT | Option 3 and Option 4 | Regarding to two benefits mentioned by MTK:  1) For the many to one mapping, we have the same view as OPPO, there is no strong motivation.  2)For the multi-hop case, it is related to the combination of UE-to-UE relay and UE-to-Network, which is not in the scope of the current SID and there is no enough time to complete the specification on it. Hence it is suggested to not consider it in the beginning. |
| Apple | Option 1 | I think the adaptation layer is needed over PC5, this helps :1) maintain the same protocol stack for U2N and U2U relay; 2) future extensible for multi-hop relay cases.  Note that having adaptation layer in PC5 interface does not necessarily mean the adaptation header must be inserted between RLC and PDCP. For single hop U2N relay, the adaptation header over PC5 interface is not needed. |
| Sony | Option 1 | Agree with others that adaptation layer is required for bearer mapping and to have a unified protocol stack for U2U and U2N. |
| ZTE | Option 1 | Considering there may be both relay traffic and normal PC5 traffic (terminated at relay UE) between remote UE and relay UE, the relay UE/remote UE needs to identify whether a packet is terminated or relay traffic. To achieve this, different PC5 LCHs/RLC bearers can be used for normal PC5 traffic and relay traffic but the PC5 LCID space needs to be extended as OPPO pointed out, or many-to-one mapping can be considered where the PC5 adaptation layer is needed. |
| Convida | Option 1 | 1. In reference to the SI objectives and requirements in terms of QoS and Security functionalities, as we indicated in Question 1a, at the minimum, the U2N relay should have an adaptation layer over Uu interface in support of remote UE identification and bearer mapping (including many to one mapping between remote UE RB and Uu RB. PC5 RLC channel or RB). 2. Adaptation layer over PC5 for L2 U2N relay is also needed. An adaption layer over PC5 for an L2 U2N relay, same as the one over Uu interface (including support for remote UE identification and bearer mapping including many to one mapping between remote UE RB and PC5 RLC channel) will provide a unified protocol design between U2U and U2N relay, since for U2U relay, an adaption layer will be needed over PC5 interface for the same reasons it is needed for U2N relay over Uu interface. 3. It will also provide support for forward compatibility for multi-hop relay support in a future release. 4. For a remote UE that is not acting as a U2U relay the adaptation layer may be optional, which also implies for the U2U relay serving an end destination remote UE i.e. a remote UE not acting as a U2U relay, the adaptation layer may be optional for that U2U relay as well and this should be something that is configurable, however this could mean extra complexity which is not desirable.   IAB BAP design should be used as a starting point but with the assumption that GTP/UDP (in the control plane) or (SCTP) are not used and this need to be taken into account. |
| Interdigital | Option 1 | We think the adaptation layer would be beneficial to allow both Uu traffic and PC5 traffic to be carried at the remote UE without issues at LCID space. Similar issue was addressed at the relay UE in FeD2D with adaptation layer between the relay and the NW. |
| Intel | Option 2 | We agree with the comments from above companies that while there can be benefits of having the adaptation layer over PC5 (in terms of flexibility and future proofing), but the complexity of introducing the adaptation layer should also be taken into account. We wonder if as a compromise, the adaptation layer over Remote UE can be considered optional and we can consider it in detail during WI phase vs other options.  We are also not sure why option 4 needs to be considered in these choices since as mentioned, it is already part of the SA2 TR and is needed anyway for remote UE’s bearer mapping. |
| Futurewei | Option 1 | It can be configured for 1-to-1 mapping (basically disabled) and m-to-1 mapping, leading to the most flexibility and control of network. |
| Lenovo&MM | Option3 | The adaptation layer is not needed over PC5 between the remote UE and relay UE.  For the many-to-one mapping between UE bearers and PC5 RLC, We don’t see the need to support this multiplexing. The current number of PC5 RLC channels is sufficient as legacy V2X.  In the case of U2N relay, the traffic (relay as termination) is ‘little’. In IAB, this kind traffic is OAM traffic. The traffic (relay as termination) could be RRC signaling for maintaining the PC5 RRC connection.  Furthermore, if the adaptation layer is introduced in the remote UE, more thing should be considered in the design of protocol stack format. |
| Fujitsu | Option1 | The adaptation layer may be put at both remote UE and relay UE. We believe, however, the adaptation layer at relay UE is more necessary than that at the remote UE, due to the necessity of many to one mapping. It should be further studied in SI. |
| Samsung | Option 3 | We do not think that adaptation layer is needed over PC5. There is no need for N:1 mapping over the PC5 link. As to what some companies are saying about forward compatibility for future multi-hop scenarios, we fail to see how this affects the PC5 link – presumably multi-hop will mean a chain of multiple Uu links? Even for IAB (which is multi-hop from the outset), the access link does not support the Adaptation layer – its purpose (routing and bearer mapping) ends at the access relay node. |
| Nokia | Option 2 with comments | Using or not using adaptation layers have its pros and cons. While using adaptation layer can provide scalability for multi-hop scenarios, it can also cause extra overhead for single-hop scenarios. Using existing methods and L2 IDs could also be possible to address this case. |
| vivo | Option 3 and option 4 | As the above comment in Q1a. |
| LG | Option 1 | Considering the unified protocol stack with the UE-to-UE relay, we think that the adaptation layer has to be allowed between remote UE and relay UE for the UE-to-NW relay. |
| Fraunhofer | Option 1 | We share the same opinion as OPPO. |

## Protocol stack for L2 UE-to-UE Relay

In [23], specific to L2 UE-to-UE relay, it is described that the traffic of one or multiple Remote UEs may be mapped to a single DRB of PC5 interface of the UE-to-UE Relay UE. Multiple SL DRBs may be used to carry traffic of different QoS levels (QoS flows) for one or multiple Remote Ues.

Then a relevant question as abovementioned (i.e. Question 1a) needs also be answered for L2 UE-to-UE relay case. However, before that, it would be helpful to confirm the need of adaptation layer over PC5 in order to describe the protocol stack for L2 UE-to-UE relaying. It should be noted that there are two PC5 links for L2 UE-to-UE Relay case, i.e. PC5 link between transmitting Remote UE and Relay UE, and PC5 link between Relay UE and receiving Remote UE. The discussion here is about the adaptation layer support over PC5 link between Relay UE and receiving Remote UE (i.e. the ingress link for Relay UE).

**Question 2a: Which option do you prefer with regard to the need of adaptation layer over PC5 for L2 UE-to-UE Relay? Please give your explanation for your choice:**

**Option1: The adaptation layer is needed over PC5 link (between Relay UE and receiving Remote UE)**

**Option2: The adaptation layer is optional needed over PC5 link (between Relay UE and receiving Remote UE)**

**Option3: The adaptation layer is not needed over PC5 link (between Relay UE and receiving Remote UE)**

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| MediaTek | Option1 | The traffic of one or multiple Remote Ues may be mapped to a single DRB of PC5 interface between the UE-to-UE Relay UE and receiving Remote UE. |
| Qualcomm | Option 1 with comments | Agree with MediaTek that it is needed for many to 1 bear mapping between relay and remote receiving UE.  Meanwhile, we don’t think it is needed between remote transmitting UE and relay, which is similar to our preference on protocol stacks of L2 UE-to-NW relay |
| OPPO | 1 | Adaptation layer is needed if the relay UE is serving multiple transmitting Ues for a same receiving UE, and if the traffic is to be carried on a same link (i.e., a pair of source / destination UE pair), an adaptation layer is necessary to differentiate the transmitting UE and bearers. |
| Xiaomi | Option1 | Similar as relay to network link. |
| Ericsson (Tony) | Option1 | This question is not crystal clear either. Is the question related to ingress link or egress link? Anyway, for egress link, the adaptation layer is needed at the relay UE to identity the packet is from where and to where.  For ingress link, the adaptation layer is needed at the remote UE for forward competitivity (for example, multiple hop U2U will be supported). |
| Huawei | Option 1 |  |
| CATT | Option1 | We have the same view as OPPO. |
| Apple | Option 1 | We think the adaptation layer is needed for both of the two PC5 links in U2U relay. |
| Sony | Option 1 |  |
| ZTE | Option 1 | Agree with MTK and OPPO, the adaptation layer is needed for the receiving remote UE to differentiate the transmitting remote UE and bearers. |
| Convida | Option 1 | See our feedback to Q1d. |
| Interdigital | Option 1 | Multiple remote transmitting UEs may be transmitting to the same remote receiving UE, and so for the same reason as UE to NW relay case, the adaptation layer is needed between the relay and remote receiving UE. |
| Intel | Option 1 | We have the same view as OPPO |
| Futurewei | Option 1 |  |
| Lenovo&MM | Option1 | The bearers from the different transmitting remote UE can be mapping to the same PC5-DRB between the relay and the receiving UE. |
| Fujitsu | Option-1 | Similar to UE-to-NW. |
| Samsung | Option 1 | Same view as OPPO. |
| Nokia | Option 1 with comments | See our comments in Q1a |
| vivo | Option 1 | For UE-to-UE relay case, we think N-to-1 bear mapping between remote receiving UE and relay UE may be needed because there may be more than one relaying pairs between relay UE and remote receiving UE. Bearer aggregation will increase resource efficiency via packet multiplexing and reduce the maximum number of bearers in relay UE.  For routing function, as in SA2’s TR23.752, relay UE may maintain the mapping table of destination ID between the remote transmitting UE and the remote receiving UE (for both direction of data transmission) in one-hop case. But adaptation layer will be useful for future multiple-hop cases. |
| LG | Option1 | The adaptation layer is needed over PC5 link for UE-to-UE relay (between relay UE and receiving remote UE). Several transmitting remote UE can be connected with one receiving remote UE via relay UE for the UE-to-UE realy. In this case, the adaptation layer over PC5 link between relay UE and receiving remote UE has to identify the transmitted link and map bearers. |
| Fraunhofer | Option 1 | The adaptation layer is required over the PC5 link between the relay and receiving remote UE for transmitting UE traffic differentiation similar to the case for the UE2NW relaying. |

Based on the discussion of question 2a, we can discuss the placement of adaptation layer over PC5 link between Relay UE and receiving Remote UE as below if the answer of question 2a is Option1 or Option2.

**Question 2b: Do you agree that the adaptation layer is put over RLC sublayer for both CP and UP for L2 UE-to-UE relaying between Relay UE and receiving Remote UE? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | No | As we comment in Q2a, we think it is sufficient to have adaptation layer over PC5 RLC between relay and receiving remote UE. And it should be aligned with L2 UE-to-NW relay protocol stacks  Below is an example of UP protocol:    **Update in v13:**  After clarification and question change from rapporteur, we are fine with this question.  We agree with Huawei’s comments on bi-direction traffic. Note that for the example figure we show, it is only for one direction, which is intended to illustrate UE-to-UE relay should be aligned with L2 UE-to-NW relay protocol stacks. |
| OPPO | Yes | Although the question is misleading: “**the adaptation layer … between two Remote Ues**” i.e., different from the question 2a, about “**between Relay UE and receiving Remote UE**”… |
| Xiaomi | Yes | Different from U2N, one transmitting remote UE may connect to multiple receiving remote Ues via U2U relay. In this cse, we see the benefit of many to one mapping on both links. |
| Ericsson (Tony) | Yes |  |
| Huawei | Yes | We understand the comments from QC, but we may also have the bi-direction traffic, where one remote UE can be both the transmitting and receiving remote UE. Technically, the comments from QC is correct. But, we don’t need to capture that details in the TR. The general protocol stack clarifies that both remote Ues MAY have the adaptation should be sufficient. |
| CATT | Yes | We reckon that it is sufficient to have adaptation layer over PC5 RLC between relay and receiving remote UE. |
| Apple | Yes |  |
| Sony | Yes |  |
| Convida | Yes | As per our feedback to Q1a, Our understanding of this question is straightforward, and that is if there should be an adaptation layer over RLC for both CP and UP between two remote UEs separated by an L2 U2E relay and the answer is yes because the U2U relay should have an adaptation layer in support of remote UE identification and bearer mapping. |
| Interdigital | Yes |  |
| Intel | Yes |  |
| Futurewei | Yes |  |
| Lenovo&MM | Yes | One transmitting UE may transmit the data to multiple receiving UE using a single relay. Therefore, this case is different from the U2N relay. |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes | We are still in doubt whether the Adaptation layer is needed for UE-UE, but can agree to HWs understanding that it may be needed, but that we may not need to capture this in details in the TR |
| vivo | Yes |  |
| LG | Yes | In the UE-to-UE relay case, the adaptation layer over RLC sublayer needs all transmitting/receiving remote UE and relay UE. Because multiple bears/IDs of transmitting remote UE can be mapped one bear/ID of receiving remote UE or one bear/ID of transmitting remote UE can be mapped multiple bears/IDs of receiving remote UE. |
| Fraunhofer | Yes |  |

With regard to the placement of the protocol layers for L2 Relaying. A relevant question as abovementioned (i.e. Question 1c) needs also be answered for L2 UE-to-UE relay case.

**Question 2c: Do you agree that in case of L2 based UE-to-UE Relay, SL SDAP/PDCP and RRC are terminated between two Remote UEs, while RLC, MAC and PHY are terminated in each PC5 link? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes | It is illustrated in our example figure in Q2b |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Yes |  |
| Huawei | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Sony | Yes |  |
| ZTE | Yes |  |
| Convida | Yes |  |
| Interdigital | Yes |  |
| Intel | Yes |  |
| Futurewei | Yes |  |
| Lenovo&MM | Yes |  |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes | If we can justify the need for the Adaptation layer |
| vivo | Yes |  |
| LG | Yes |  |
| Fraunhofer | Yes |  |

The discussion on the need of adaptation layer over PC5 should be also applicable to L2 UE-to-UE Relay, RAN2 needs to confirm this in order to describe the protocol stack for L2 UE-to-UE relaying. It should be noted that there are two PC5 links for L2 UE-to-UE Relay case, i.e. PC5 link between transmitting Remote UE and Relay UE, and PC5 link between Relay UE and receiving Remote UE. The discussion here is about the adaptation layer support over PC5 link between transmitting Remote UE and Relay UE (i.e. the egress link for Relay UE).

**Question 2d: Which option do you prefer with regard to the need of adaptation layer over PC5 for L2 UE-to-UE Relay? Please give your explanation for your choice:**

**Option1: The adaptation layer is needed over PC5 link (between transmitting Remote UE and Relay UE)**

**Option2: The adaptation layer is optional needed over PC5 link (between transmitting Remote UE and Relay UE)**

**Option3: The adaptation layer is not needed over PC5 link (between transmitting Remote UE and Relay UE)**

**Option4: Other way (please specify)**

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| MediaTek | Option1 | The role of transmitting Remote UE can be also receiving Remote UE for the data stream at opposite direction. Then if the answer of Question 2a is Option1, the answer to this question should be also Option1. |
| Qualcomm | Option 3 | As we comment in Q2a, we think it is sufficient to have adaptation layer over PC5 RLC between relay and receiving remote UE. And it should be aligned with L2 UE-to-NW relay protocol stacks |
| OPPO | 1 | Basically, the same argument used for 1d above is applicable here, i.e., adaptation layer is needed considering the need to carry not only the 1-hop relayed traffic, but also the traffic between transmitting UE and relay UE directly, and the multi-hop traffic. |
| Xiaomi | Option 1 | Different from U2N, one transmitting remote UE may connect to multiple receiving remote UEs via U2U relay. In this cse, we see the benefit of many to one mapping on both links. |
| Ericsson (Tony) | Option1 | We are okay to have the adaptation layer on the relay UE and remote UE.  See more comments for Q2a. |
| Huawei | Option 1 | See our comments in Q2a. |
| CATT | Option3 | See our comments in Q2b. |
| Apple | Option 1 | See our comments in Q2a |
| Sony | Option 1 |  |
| ZTE | Option 1 | If the relay UE is serving multiple receiving/destination UEs for a same transmitting UE, and if the traffic is to be carried on a same link (i.e., a pair of source / destination UE pair), an adaptation layer is necessary between the transmitting UE and the relay UE for the relay UE to differentiate the receiving/destination UE and bearers. |
| Convida | Option 1 | See our feedback to Q1d |
| Interdigital | Option 1 | Similar to our comments in Q2a. |
| Intel | Option 2 | Same comment as in Q2a. |
| Futurewei | Option 1 |  |
| Lenovo&MM | Option1 | One transmitting UE may transmit the data to multiple receiving UE using a single relay. Therefore, this case is different from the U2N relay. |
| Fujitsu | Option1 | In this case, it is beneficial to have many-to-one mapping from transmitting UE to relay UE. |
| Samsung | Option 3 | The way the question is phrased, strictly speaking we believe Option 3 is the right way to go. But the question does not take into account potential bi-directionality of the scenario. |
| Nokia | Option 3 | See comments in Q2a |
| vivo | Option 3 |  |
| LG | Option 1 | Different from UE-to-NW, one transmitting remote UE can set link establishment with several receiving remote UE via relay UE. In this case, the adaptation layer over PC5 between transmitting remote UE and relay UE has to identify receiving remote relay UE. |
| Fraunhofer | Option 1 | The transmitting remote UE may also receive from the opposite direction. Having the adaptation layer can bring more flexibility to the application of UE to UE relay. |

## Functionality of Adaptation layer

An adaptation layer is supported in Uu between Relay UE and the network to perform bearer mapping for L2 UE to network relaying. The adaptation layer between the Relay UE and gNB is able to map multiple end-to-end Radio Bearers (SRBs, DRBs) of a particular Remote UE and/or different UEs into one Radio Bearer over the direct Uu path. If the adaptation layer over PC5 is supported for L2 UE-to-Network and L2 UE-to-UE relaying, the adaptation layer mainly functions as bearer mapping between end-to-end Radio Bearers and PC5 RLC channels when considering only one-hop case. In summary, the basic functionality of adaptation layer should be bearer mapping.

There is also an understanding to support packet routing function at adaptation layer. The packet routing function includes the following cases:

* In case of L2 UE-to-Network relay, for downstream transmission from gNB to Remote UE, the Relay UE needs to route the packets to the correct Remote UE
* In case of L2 UE-to-UE relay, for data transmission from one Remote UE to another, the Relay UE needs to route the packets to the correct Remote UE
* In case of multiple hop relaying (both L2 UE-to-Network relay and L2 UE-to-UE relay), the Relay UE needs to perform packet routing function as supported by IAB node.

In addition, in [7], it is proposed to adopt the local ID based packet routing in order to support forward compatibility of L2 based relaying operation.

It should be noted that packet routing function is needed when considering multi-hop case for L2 relaying. However, the multi-hop case may be not the priority case for Rel-17 SL relay study. It is a need to clarify the basic functionalities of adaptation layer for L2 relaying.

**Question 3: Which option do you prefer with regard to the actual functionality set of adaptation layer for L2 Relaying? Please give your explanation for your choice:**

**Option1: Bearer mapping only**

**Option2: Bearer mapping and packet routing**

**Option 2a: Bearer mapping and one-hop packet routing**

**Option3: More functions need to be considered (with reference to BAP for IAB)**

**Option4: No need to clarify it at study stage**

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| MediaTek | Option1 | In case of one-hop, we assume that in order to support bearer mapping, Relay UE needs to maintain a mapping table between ingress channel/RB and egress channel/RB, where the identity of Remote UE may be included. We also assume that the identity of Remote UE should be populated along the relaying communication path and then this identity can be also used to find the right destination of the data packets. So then it seems that if bearer mapping is supported, the mentioned packet routing is supported for free.  If the multiple hop relaying case is not considered at Rel-17, the explicit packet routing may be not very much essential. |
| Qualcomm | Option 1 | Please note that multi-hop is not in scoping of Rel-17 SI. We may have some consideration on how to leave some room for future extension to multi-hop, but we need to only support one-hop in this release. |
| OPPO |  | It is not clear definition for the bearer mapping and routing. Our understanding of the adaptation layer is (taking U2N relay as an example)  For UL: mapping from PC5 RLC channel to Uu RLC channel at relay, identifying source node (i.e., remote UE) and/or bearer ID at RAN;  For DL: mapping from Uu RLC channel to firstly specific remote UE, and secondly the PC5 RLC channel at relay (somehow one can understand 1st part as routing and 2nd part as mapping), identifying source node (i.e., RAN/relay UE) and/or bearer ID at remote UE. |
| Xiaomi | Option2 | If we support multiple SLRBs from different remote UEs to one DRB mapping, packet routing is necessary to support. Otherwise, relay/gNB is not able to route RLC SDUs to correct remote UE’s RLC/PDCP.  I also agree with MTK the routing can be achieved together with bear mapping. |
| Ericsson (Tony) | Option2 | We agree with MediaTek, but we also think that for future proofing it would be better to have packet routing already now.  This is also in line with what stated in the SID:  NOTE 3: Forward compatibility for multi-hop relay support in a future release needs to be taken into account.  Even for single hop case, packet routing is needed to distinguish flows/packets terminated at the relay UE and flows/packets terminated at the receiving remote UE. |
| Huawei | Option 2 | Even in single hop case, for DL, relay UE needs to decide that each packet should be routed to which remote UE. This is the packed routing.  In general, we can say adaption layer can support the “**Bearer mapping and packet routing**”, but we can decide if those two functions can be achieved together as one functions in WI phase. |
| Option 2a | Based on the comment from other companies, we believe option 2a could be the compromised way. The way forward could be:  **In L2 relay, adaptation layer includes functions of bearer mapping and one-hop packet routing. FFS whether to combine those two into one functions in the specification can be decided in WI phase.** |
| CATT | Option1 | Due to many limitations, we reckon that we’d better focus on one-hop at the current stage. |
| Apple | Option 2 | I think the difference in “bearer mapping” and “packet routing” is very clear. This depends on how adaptation header is designed in U2U and U2N relay. So far, we can deem both are supported in adaptation layer in general |
| Sony | Option 1 | Agree with Mediatek |
| ZTE | Option 2 | As above commented, the definition of the bearer mapping and the routing is not so clear, and the routing can be achieved when bearer mapping is supported. In addition, we share the same view as Ericsson, packet routing is needed to distinguish packets terminated at the relay UE or relayed traffic. |
| Convida | Option 2 | We share the same view with Ericsson |
| Interdigital | Option 2 | Packet routing functionality is needed at least for DL of UE to NW relay and for UE to UE relay. Multihop routing functionality can be discussed in future releases. |
| Intel | Option 2 | We share the view with companies supporting Option2 |
| Futurewei | Option 2 | There seems to be different understanding of Option 1, and not all companies consider routing to a particular UE is part of bearer mapping. Hence, option 2 would make it clear that adaptation layer needs to take care of routing data to potentially multiple UEs. |
| Lenovo&MM | Option2&Option3 | In order to support forward compatibility for multi-hop relay support, routing should be supported in the new layer.  Whether more function should be considered in the adaptation layer is too early to rule out. |
| Fujitsu | Option1 | We don’t see any necessity of packet routing in Rel-17. |
| Samsung | Option 1/2a | Routing function is not necessary for Rel-17 SI (= single-hop). There could be some benefit in a forward-looking design which incorporates the routing function from the outset, but routing is an almost independent function to bearer mapping and can be realized later. Option 2a is also acceptable, assuming we can clarify what one-hop routing is. |
| Nokia | Option 1(2a) | As we consider the fact that Rel17 SI should be for single hop only. In respect to the Note 3 in the SI provided by Ericsson, then the future proofing could simply mean not to go for changes which would make routing difficult. |
| vivo | Option 1 | Bearer mapping only is enough at least for Rel-17 since we only support one-hop relaying. The one-hop routing could be further considered, if needed. |
| LG | Option1 | We agree with Media Tek’s opinion. If the bearer mapping is supported, the packet routing is supported for free. |
| Fraunhofer | Option 2 | We share the view with Ericsson. |

## Bearer mapping

The support of bearer mapping at adaptation layer requires the specific design of the header of adaptation layer. With regard to the header design of adaptation layer i.e. which fields should be put into the header of the adaptation layer, there are proposals that suggest to indicate the ID of remote UE and the end-to-end Radio Bearers (SRB and DRB) of remote UE in [7] and [8] at the header of the adaptation layer, in order to allow the receiver node to perform needed Bearer mapping. In [1], it is also proposed to put the bearer information of end-to-end RB within the adaptation layer in order to enable Bearer mapping. In [6], it is proposed that the functions of the new adaptation layer include identifying transmitting node and destination node, identifying UE bearer and bearer mapping in the case of UE-to-Network relay. In [36], it is discussed that the Remote UE may be identified in the adaptation layer header on Uu by a local identifier which is known at least to the gNB and Relay UE.

It would be helpful to clarify the information that needs to be put into the header of adaptation layer (over Uu between Relay UE and gNB) from the perspective of Bearer mapping, etc. The discussion needs to cover both down-stream (from gNB to Relay UE) and up-stream (from Relay UE to gNB). RAN2 can attempts to clarify the needed information within adaptation layer for both L2 UE-to-Network relay and L2 UE-to-UE relay.

**Question 4a: Which identities in the following are needed within the header of adaptation layer (over Uu) to enable Bearer mapping for L2 UE-to-Network relay? Please give your explanation for your choice:**

(1) Identity of the Remote UE known by gNB and Relay UE (Remote UE ID or a local ID)

(2) Identity of End-to-End Remote UE RB

(3) Other Identity (Please specify, e.g. Transmitter Node ID; Destination node ID)

|  |  |  |
| --- | --- | --- |
| Company | ID List preferred | Comments |
| MediaTek | 1,2 | The Identity of the Remote UE and the Identity of Remote UE RB can uniquely address the RB for purpose of bearer mapping |
| Qualcomm | 1,3 (PC5 local RLC channel ID) | We think it may be a bit rushed to discuss contents of adaptation layer header before we confirm the requirement of adaptation layer (e.g. whether to support 1-to-1 mapping, whether to support many-to-1 mapping)  Our understanding on functionalities of adaptation layer in this release are the below 2 aspects:  • Multiplexing of Remote UE(s) traffic on Relay UE’s Uu LCHs  • Mapping traffic from Remote UE Uu SRBs/DRBs to corresponding PC5 LCHs and Uu LCHs and vice versa  Based on them, we think 1 (remote UE ID) makes sense to identify remote UE for support of many-to-1 mapping; 2 (remote UE RB ID) can work to support bear mapping from sidelink beaer to Uu bearer. But we think that it needs gNB to indicate an addition mapping for remote UE RB ID to relay, which cause extra overhead. Instead, we can just use PC5 local RLC channel ID.  We can further discuss what is the “identifier” after the functionality of adaptation layer is concluded. |
| OPPO | 1,2, 3 (RAN node ID) | At this stage, RAN node ID maybe not necessary, but in future it may be needed if considering: 1) to align the relay protocol stack with U2U L2 relay as much as possible; 2) DC architecture maybe supported in future for U2N L2 relay; |
| Xiaomi | 1, 2 | Identity of remote UE and RB is enough to do the bearer mapping and packet routing. |
| Ericsson (Tony) | 1,2 |  |
| Huawei | 1,2 | For “RAN node ID”, we can include that in future release. Let’s not include too much in the adaptation header, which is not necessary in this realize. Anyway, we will have some reserve bit in adaptation header for future extension (e.g. adding more ID)  Also, “PC5 RLC channel ID” is not configured by gNB in current NR SL design. This option would cause the LCID reporting to gNB. Actually, if we have the 1:1 mapping from Uu RB to PC5 RLC, the Uu RB ID has same meaning as the PC5 RLC ID. |
| CATT | 1,2 |  |
| Apple | 1,2 |  |
| Sony | 1,2 |  |
| ZTE | 1,2 |  |
| Convida | 1,2,3 | At this point, path identity might not be needed but if RAN2 decides to support for example in the future multi-hop & multi-path (for e.g. multi-path between the relay UE and the network) a path ID might also be needed. So the design of the adaptation layer header should take this into account, which will also be in line with the following note from the SID: “Forward compatibility for multi-hop relay support in a future release needs to be taken into account.” Off course how this is taken into account is a detail header design issue that can be considered at a later stage of the work. |
| Interdigital | 1,2 | These two are aligned with discussions in FeD2D. |
| Intel | 1,2 | We can consider any additional aspects (e.g. future proof design) in the WI phase |
| Futurewei | 1,2,3 | We are open to these identities. And this level of details can be left to WI phase to sort out. |
| Lenovo&MM | 1,2 with comments | The header of adaptation layer should be used to identify the transmitting UE, destination and UE bearer.  But, the UE bearer could not be End-to-End Remote UE RB. e.g PC5 remote UE bearer is also possible. |
| Fujitsu | 1,2 |  |
| Samsung | 1 as a minimum, 2 would help with flexibility, but… | It is too soon to be having this discussion – functionalities need to be agreed first. |
| Nokia | 1,2 | As baseline |
| vivo | 1,2 |  |
| LG | 1,2 | Both the remote UE ID(or a local ID) and remote UE RB is enough to identify for bearer mapping for UE-to-NW relay. |
| Fraunhofer | 1,2 | The remote UE and RB identities are required and enough to map RBs in the adaptation layer. |

**Question 4b: Which identities in the following are needed within the header of adaptation layer over PC5 to enable Bearer mapping for L2 UE-to-UE relay? Please give your explanation for your choice:**

(1) Identity of Remote UE known by peer Remote UE and Relay UE (Remote UE ID or a local ID)

(2) Identity of End-to-End Remote UE SLRB

(3) Other identity (Please specify, e.g. Transmitter Node ID; Destination node ID)

|  |  |  |
| --- | --- | --- |
| Company | ID List preferred | Comments |
| MediaTek | 1,2 | The Identity of the Remote UE and the Identity of Remote UE SLRB can uniquely address the SLRB for purpose of bearer mapping |
| Qualcomm | 1,3 (PC5 local RLC channel ID) | Same justification for L2 UE-to-NW relay. And we should follow the guideline of SID:  ““NOTE 2: It is assumed that UE-to-network relay and UE-to-UE relay use the same relaying solution” |
| OPPO | 1,2 | For 1, we assume that both source and destination UE ID should be included. |
| Xiaomi | 1, 2 | Same as Q4a. |
| Ericsson (Tony) | 1,2 |  |
| Huawei | 1,2 | See comments above |
| CATT | 1,2 |  |
| Apple | 1,2 |  |
| Sony | 1,2 |  |
| ZTE | 1,2,4 | For the PC5 adaptation layer between the relay UE and the receiving UE, (1)(2) are needed for bearer mapping. For the PC5 adaptation layer between transmitting UE and relay UE, the identity of the receiving/destination UE and identity of end-to-end SLRB are needed for the relay UE to route the packet to correct receiving/destination UE. |
| Convida | 1,2,3 | Same comment as for Q4a |
| Interdigital | 1,2 | Same reasoning as previous question. |
| Intel | 1,2 | Same comment as for Q4a |
| Futurewei | 1,2,3 | We are open to these identities. And this level of details can be left to WI phase to sort out. |
| Lenovo&MM | 1,2,3 | The header of adaptation layer should be used to identify the transmitting UE, receiving UE and UE bearer. |
| Fujitsu | 1, 2 |  |
| Samsung | 1 (&2) | But again it is too early to be discussing this. |
| Nokia | 1,2 | But agree it is to early to discuss |
| vivo | 1,2 |  |
| LG | 1, 2 | Same as Q4a. |
| Fraunhofer | 1,2 | Same as the adaptation layer in UE to Network relay. |

## Basic aspects for connection setup for UE-to-NW relay

It is necessary to reuse the PC5 unicast link establishment procedure to support the unicast communication between the L2 remote UE and relay UE. Only after successful PC5 unicast link setup, L2 remote UE and relay UE can exchange the remote UE control plane and user plane traffic. It means Rel-16 NR V2X PC5 unicast link establishment procedures can be reused to setup a secure unicast link between Remote UE and Relay UE for L2 relay option [1]. The remote UE can then establish a Uu RRC CONNECTION via a UE-to-NW relay once the PC5-RRC connection for relaying is established with the relay UE [17]. RAN2 needs to confirm that this understanding.

**Question 5a: Do you agree that Rel-16 NR V2X PC5 unicast link establishment procedures can be reused to setup a secure unicast link between Remote UE and Relay UE for L2 relaying (before Remote UE establishes a Uu RRC CONNECTION with the network via Relay UE)? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes | It makes sense to reuse Rel-16 NR V2X procedure, at least to reduce spec work. We don’t think it is necessary to introduce new procedure for unicast PC5 link establishment for L2 relay.  Furthermore, we think it is better to have a unified PC5 link establishment procedure for L2 and L3 relay. Please note that SA2 has specified that a unicast PC5 link establishment procedure is needed for L3 UE-to-NW relay in section 6.6 of TS 23.752, as per the architecture recommendations in 5G ProSe SA2 TR. |
| OPPO | Yes with comment | When talking about “**Rel-16 NR V2X PC5 unicast link establishment procedures**”, apparently the PC5-S procedure part is out of RAN2 scope.. what RAN2 can decide is the reusing of AS-layer configuration and capability transfer as PC5-RRC procedure. |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Yes with comment | We do not see the need to change something that is already working.  However, we may need to study if additional information may be provided during link establishment to help the remote UE and relay UE to establish the PC5-RRC for the relay path (e.g., if remote UE forward traffic information the relay UE may inform right away that he is not able to handle the traffic of the remote UE, if a PC5-RRC is established). |
| Huawei | Yes | The proposal from rapporteur is the correct/good baseline. Further study or impacts can be considered in WI phase. |
| CATT | Yes | Agree with OPPO. |
| Apple | Yes | At the current stage, I think it is fair to say the existing R16 PC5-RRC procedures for direct link setup is the baseline. Additional parameters/IE may be added in WI stage. |
| Sony | Yes | Agree with Ericsson that we need to address the scenario where a relay UE or a gNB may not be able to handle the service requested by the remote UE. |
| ZTE | Yes |  |
| Convida | Yes | Same comment as Ericsson |
| Interdigital | Yes | We also think that unicast link establishment procedures include SLRB configuration.  We agree with the scenario from Ericsson – it can be studied further in the WI phase. |
| Intel | Yes | It can be considered as baseline |
| Futurewei | Yes |  |
| Lenovo&MM | Yes | Agree with Oppo |
| Fujitsu | Yes |  |
| Samsung | Yes | As a baseline. |
| Nokia | Yes | As baseline |
| vivo | Yes with comment | We agree the intention. But SA2 was discussing whether the discovery and establishment procedure can be merged together. RAN2 needs to wait for SA2’s further progress. |
| LG | Yes | There is no reason not to reuse Rel-16 NR V2X PC5 unicast link establishment procedures for secure link setup between remote UE and relay UE. |
| Fraunhofer | Yes | We think a new procedure is not necessary for PC5 unicast link establishment. Same procedure as Rel.16 can be used. |

**Discussion on SRB0 configuration for Remote UEs in cellular coverage**

[7] suggests that for SRB0 of the Remote UE, Uu RLC bearer configuration for the Relay UE can be predefined by specification and differentiated from the ones for the Relay UE’s SRBs. In rapporteur understanding, the SRB0 configuration for Remote Ues in cellular coverage can be configured by pre-configurations, broadcast based mechanism (i.e. SIB based distribution) and/or dedicated RRC signaling based approach.

**Question 5b-1: Which option(s) do you prefer for the configuration of Uu SRB0 of the Remote UE (in coverage)?**

Option1: pre-configurations

Option2: Broadcast based mechanism (i.e. SIB based distribution)

Option3: Dedicated RRC signaling

Option4: Fixed parameters in the specification

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Option1/2 |  |
| Qualcomm | See comments | The question is not clear. First, remote UE can’t use Uu SRB0 when it is in OOC, right? Secondly, we are not sure what “predefined by specification” means, e.g. is it pre-configuration or default configuration. Some clarifications are needed.  **Update in v13:**  After clarification from rapporteur, please see our response in Q5b-3 |
| OPPO |  | We understand it is not possible to always rely on dedicated RRC to configure the related PC5 parameter considering this procedure happens before connection establishment.  While we are open to fixing it in spec, we wonder why pre-configuration does not work if the remote UE is OOC, and why SIB configuration does not work if the remote UE is in-coverage? |
| Xiaomi | No | According to previous question, remote UE shall establish sidelink unicast connection before establishing Uu connection. If so, the SRB0 configuration could be configured by relay via sidelink unicast. |
| Ericsson (Tony) | Option2 and Option3 with comment | We think that this question is only valid in certain use cases/scenarios on when the remote UE is out of coverage.  However, we need to address also the case when the remote UE is out-of-coverage and, in this case, there is no SRB0 for the remote UE.  In such a case, we may rely on relay UE using the SRB0 for establishing the relay path (i.e., if the relay in IDLE or INACTIVE).  On top if this, we believe that also the cases when the remote UE is out-of-coverage should be addressed.  UPDATED REPLY: We still do not get the discussion on this SRB0. However, if the remote UE is in coverage, our assumption is that the gNB is in full control of whether the remote UE should use the direct Uu connection or the relay path. According to this, pre-configuration is not suitable.  Option2 and Option3 are the suitable candidate as the gNB can configure the remote UE via SIB or via dedicated signaling. |
| Huawei | Option 4 | Fixing the parameters in the spec is the simple way and the principle from R16 SL design and R16 Uu design.  Please note, for legacy Uu SRB0 and legacy SL SRB0, fixed parameters are used. We see no need of any further enhancement or flexibility from NW configuration.  **Again, this has no relationship on whether remote UE is IC or OOC. SRB0 configuration should be always fixed in the spec, as in legacy SL and legacy Uu.** |
| CATT | Option1/2/4 |  |
| Apple |  | It is not clear what does Uu SRB0 mean here for in-coverage UE? If it is for the direct path to gNB, then we just reuse the legacy Uu procedure. If it means how msg 3 is transported via relay UE in indirect path, not sure what exact configuration is to be discussed here because no security, no PDCP, no RLC configuration are needed for the virtual “end-to-end” SRB0. |
| Sony | 1/4 |  |
| ZTE | Yes | Predefined by spec is simple. |
| Convida |  | Too early to decide this. Configuration fixing in the spec as well as the use of other possible methods such as the one alluded to by OPPO or Xiaomi should be discussed further. |
| Interdigital | 4 | We think this is mostly inline with current Uu and SL SRB0 configuration. |
| Intel | See comment | We are not sure why we have to combine all the configurations and follow only one method at this stage. PC5 configuration could follow Rel 16 as baseline, i.e. depending on Remote UE coverage. As for Uu configuration, Uu SRB0 can follow Uu spec as baseline (i.e. predefined in specification). |
| Lenovo&MM | 3,  dedicated RRC signaling in PC5 interface and Uu interface. | Before ‘first RRC message for connection establishment from Remote UE with gNB’ is sent, PC5-RRC between remote UE and U2N relay and dedicated SRB in Uu have been established. Therefore, this first RRC message can be transmitted in the dedicated SLRB. For example, it can be capsulated in RRCReconfigurationsielink message. |
| Fujitsu | Optin2 and 3 | It works in IoC. |
| Samsung |  | Legacy procedure. |
| Nokia | Option 2 or 3 |  |
| vivo | 1/2/4 | At this stage option 1/2/4 seems all OK to us and should not be excluded. Down-selection among them (if needed) could be further for study. |
| LG |  | We have the same opinion with Apple. The question is not clear. If the question means how msg3 of remote UE is transported via relay UE, we think the remote UE can use Uu SRB0 which can be the same SRB0 used by relay UE because SRB0 is carried by common CCCH which any UE can use. |

**Discussion on SRB0 configuration for Remote Ues out of coverage**

We need also discuss the handling for SRB0 for Remote Ues at out of coverage. There are multiple options to handle the issue. At first the SRB0 configuration can be defined by pre-configuration and then SRB0 can be initiated by Remote UE as legacy procedure but applying the pre-configured parameters. Secondly, Relay UE can inform the SRB0 configuration to the Remote Ues based on the established unicast PC5 link. In this way, Relay UE may get the SRB0 configuration from the network ahead of the PC5 based SRB0 configuration distribution. Thirdly, we may rely on relay UE to establish the relay path between Remote UE and gNB, which means when the two direct links are available, the indirect link is assumed to be available.

**Question 5b-2: Which option(s) do you prefer for the configuration of Uu SRB0 of the Remote UE (out of coverage)?**

Option1: Pre-configurations

Option2: Relay UE can inform the SRB0 configuration to the Remote Ues

Option3: implicit establishment (relying on relay UE to establish the relay path)

Option4: other way (Please specify)

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Option1 |  |
| Ericsson (Tony) | Option1 or Option3 with comment | We think that the options and the question are not correctly formulated.  If the remote UE is OoC is not clear to us how it would be possible to establish a Uu SRB0 even with pre-configuration.  Pre-configuration is of course possible, but to establish a PC5-RRC with the relay UE.  Our understanding is that the remote UE should rely on the relay UE to establish the relay path and get the necessary information/procedure (e.g., SIBs or paging).  If this is the understanding, Option1 and Option3 are more suitable, even if not crystal clear what they really mean in the way they are formulated. |
| Huawei | **Option4**: Fixed parameters in the specification | See comments above. |
| CATT | Option1 |  |
| Apple | No need of configuration for remote UE | See comments above |
| Spny | Option 1/4 | Option 4- fixed parameters in the spec |
| ZTE | Yes |  |
| Convida |  | See comments for 5b-1 |
| Interdigital | Option 4 | Same as our answer for previous question. |
| Intel | Option 1/2 | Same comment as for Q5b1 |
| Lenovo&MM | 4 | Before ‘first RRC message for connection establishment from Remote UE with gNB’ is sent, PC5-RRC between remote UE and U2N relay and dedicated SRB in Uu have been established. Therefore, this first RRC message can be transmitted in the dedicated SLRB. For example, it can be capsulated in RRCReconfigurationsielink message. |
| Samsung |  | SRB0 not used for OOC Remote Uu. |
| Nokia | 1 or 3 |  |
| vivo | Option 1/4 |  |
| LG |  | Same comment above |

**Updated Question for Q5b-1/5b-2 according to the email discussion**

According to the clarification with email, there is a confusion on whether OOC remote UE can use Uu SRB0, which is a terminology issue.

OOC remote UE should be able to send RRCSetupRequest message to gNB (relayed by Relay UE). We can call this signaling as SRB0, as there is no actual Uu RRC connection yet and there is no Uu SRB1/2 yet between Remote UE and gNB. However, in the terminology of Uu SRB0, it is featured by two aspects: (1) it is the first batch of RRC messages between UE and network (2) it is carried by CCCH. If we strictly apply the Uu SRB0 characteristics to Remote UE SRB0, it is not fully identical with the following reasons:

(1)   “Remote UE SRB0” may be not carried by the PC5 CCCH, and there is no need to do so as there is already unicast PC5 link before the establishment of Uu RRC for Remote UE

(2)   “Remote UE SRB0” may be not carried by the Uu CCCH (between Relay UE and gNB) and the relay UE may use SRB1/2 or DRB to forward the “Remote UE SRB0” over the air to gNB.

Based on the reasons as explained above, someone can say “Remote UE SRB0” is not SRB0. The rapporteur thinking is we need not be stuck by terminology, instead we should focus on the discussion on the functionality. If we change the “Remote UE SRB0” to “first RRC message for Uu connection establishment from Remote UE”. The confusion may be resolved.

It is also needed to clarify that specific to the case where Remote UE is in coverage, there is a possibility for Remote UE to send the “first RRC message for Uu connection establishment” to gNB via relay UE. “Remote UE In coverage” does not mean this Remote UE can always establish or maintain the Uu RRC with gNB without relaying (e.g. uplink restriction for cell edge UE). Meanwhile for the in-coverage remote UE, I think we cannot exclude that the RRC message over “SRB0” can be sent directly to the gNB. For the time being, both approaches (RRC directly to the gNB or via the relay UE) should be on the table and we should not down-prioritize one of the other.

Option1 (pre-configurations) and Option4 (Fixed parameters in the specification) as described in Q5b-1/5b-2 is the same. Both Option1 and Option4 mean new specification work (e.g. new default configuration with at least PC5 MAC/RLC config). The current 9.3/9.2 of 38.331 cannot simply apply.

Based on the discussion, the following proposals are made.

**Proposal 1: Use “first RRC message for connection establishment from Remote UE with gNB” to replace “Remote UE SRB0” to resolve the terminology issue.**

**Proposal 2: The configuration for transmitting “first RRC message for connection establishment from Remote UE with gNB” can be based on default configuration (specified in specs)**

**Proposal 3: Both P1 and P2 apply to both OOC and IC Remote UEs**

Then further company inputs can be based on Question 5b-3 for the same discussion as Question 5b-1/5b-2.

**Question 5b-3: Do you agree with following description for the connection establishment from Remote UE with gNB?**

* **Use “first RRC message for connection establishment from Remote UE with gNB” to replace “Remote UE SRB0” to resolve the terminology issue.**
* **The configuration for transmitting “first RRC message for connection establishment from Remote UE with gNB” can be based on default configuration (specified in specs)**
* **The description above applies to both OOC and IC Remote UEs**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| OPPO |  | For the second/third bullets: Here we understand there are following ways to implement the configuration:   1. Pre-configuration 2. SIB 3. Dedicated RRC 4. Specified configuration 5. Default configuration   Firstly, please note that specified configurations are fixed while default configurations can be modified using dedicated signaling, so 4/5 are separated options. Then, w.r.t. the configuration of SRB0, since there is no PDCP, the configuration is only for RLC/MAC/PHY of remote UE for PC5 interface:   * For IC case, 2/4 are feasible * For OOC case, 1/4 are feasible   Obviously, dedicated configuration does not work since this is the first message before RRC being connected, and default configuration is not preferred since allowing dedicated RRC to override does not bring too much benefit for SRB0 which is only used for the CCCH (similar to Uu). |
| Qualcomm | Yes in principle | For 1), we understand it is just a change of terminology to avoid confusion on the initial RRC establishment procedure of remote UE via relay. We agree with this terminology change  For 2), our understanding is that this is a new default configuration for remote UE in L2 relay. It includes at least at least PC5 MAC/RLC config, and is different from existing default config in section 9.2 and 9.3 of 38.331. We agree in high level with this new default config, but need further discussion on details  For 3), we understand that it is only for the scenario that remote UE has established PC5-RRC with relay, i.e. not involving the scenario before relay connection. With this clarification, we agree. |
| Sony | Yes |  |
| ZTE | Yes |  |
| Convida |  | Too early to decide this. Configuration fixing in the spec as well as the use of other possible methods such as the one alluded to by OPPO should be discussed further. |
| Interdigital | Yes, with clarifications | For bullet 2, we understand that this configuration refers to both   * the configuration at the remote UE (RLC/MAC/PHY) of the SL RLC bearer to carry the first RRC message * the configuration at the relay UE of the Uu RLC bearer on which to relay this message.   Given this understanding, we think the same applies not only to the first RRC message by the remote UE, but to any Uu-related RRC signaling (e.g. complete message). So the remote UE would create such a SL RLC bearer and use it for any RRC signaling subsequent to this.  As mentioned by the rapporteur, the SL RLC bearer in question cannot be SL SRB since it is not terminated in the relay. So it is instead a type of “default” RLC DRB. |
| Intel | Yes with comments | For P1, the change in terminology is fine if the intention is to remove any confusion.  For P2, we understand it as referring to the PC5 related configuration for the remote UE. If so, it is ok in principle, but we also echo OPPO’s view from the email reflector that these proposals seemed to have popped up without much discussion based on company proposals. |
| Futurewei | Yes to 1) and 3) | The “first RRC message for connection establishment from Remote UE with gNB” can be sent over PC5 RRC to relay UE for forwarding to gNB. Since PC5 RRC should already be established between the remote UE and the relay UE, there is no need of “specified or default configuration”. |
| Lenovo&MM | Yes for 1 and 3.  No for 2 | 1) “first RRC message for connection establishment from Remote UE with gNB” could be clearer.  2) Before ‘first RRC message for connection establishment from Remote UE with gNB’ is sent, PC5-RRC between remote UE and U2N relay has established. Therefore, this first RRC message can be capsulated in the legacy PC5 RRC message e.g RRCReconfigurationsielink message.  So, default configuration is not needed.  3) the common solution for the transmission of the first RRC message is expected regardless of OOC or IC. So, we agree. |
| Samsung | Yes |  |
| vivo | Yes with comments | We tend to agree with the intention.  For the above ‘first RRC message for connection establishment from Remote UE with gNB’ of remote UE, the configuration of the PDCP layer could be specified in the spec directly, e.g. TS38.331. And the RLC bearer configurations in PC5 link and relay UE’s Uu link needs to be also specified in the spec directly.  But by now, this mapping between the ‘first RRC message’ in PC5 link and relay UE’s Uu link, e.g. SRBn or DRBn, needs for further study. |

**Discussion on other RB configuration for Remote UEs**

[7] suggests that other than SRB0, the rest SRB (e.g. SRB1/2) and DRB is subject to legacy configuration procedures. [11] discusses the procedure used by for remote UE to request the PC5 configuration for relayed service(s). Both Uu based procedure and PC5 based procedure are proposed. The configuration of the Radio Bearers for Remote UE is the basic CP aspects before Relaying initiation. RAN2 is suggested to clarify the procedures.

**Question 5c: Do you agree that the Uu SRB(1/2) and DRB of the Remote UE is subject to legacy configuration procedures? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes for the principle | Agree the principle. However, some details of connection management need further discussion, e.g. what is “legacy configuration procedures” for OOC remote UE. |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Maybe with comment | We think that this question is only valid in certain use cases/scenarios on when the remote UE is out of coverage.  However, we need to address also the case when the remote UE is out-of-coverage and, in this case, there is no SRB0 for the remote UE.  In such a case, we may rely on relay UE using the SRB0 for establishing the relay path (i.e., if the relay in IDLE or INACTIVE).  On top if this, we believe that also the cases when the remote UE is out-of-coverage should be addressed. |
| Huawei | Yes | Cannot fully understand the concern on OOC from Ericsson. Even remote UE is OOC, when we talk about the SRB1/2 and DRB, remote UE has already setup the RRC connection to NW via relay. That means all the dedicated configuration manners are feasible. |
| CATT | Yes |  |
| Apple | Yes with comment | Again, I think we are talking about end-to-end Uu SRB1/2 and DRBs for remote UEs. From this perspective, the remote UE is virtually “in coverage”, so legacy Uu procedures can be reused, but I think this is mostly only for PDCP and security config because AS layers below PDCP does not physically exist end-to-end. |
| Sony | Yes |  |
| ZTE | Yes | Agree with Qualcomm, the description shall be more clearly. |
| Convida | Yes |  |
| Interdigital | Yes with comment | Once a SL RLC bearer is created to carry Uu RRC signaling via the relay UE, we agree that all configuration procedures can follow legacy as though the Uu RRC signaling is routed via the relay (rather than directly on Uu).  However, we think SRB1 and SRB2 would still need to be transmitted via the same SL RLC bearer, since the RRC connection is only established (and reconfiguration from the network is only possible) following transmission of the complete message (which is by definition sent on SRB1). |
| Intel | Yes |  |
| Futurewei | Yes with comments | Agree with Apple, RLC needs to be configured hop-by-hop for PC5 and Uu. |
| Lenovo&MM | Yes | Details should be discussed in WI. |
| Fujitsu | Yes |  |
| Samsung | Yes | So long as we take into account the revised approach detailed in Question 5b-3 for OOC UEs. |
| Nokia | Yes |  |
| vivo | Yes with comment | In L2, remote UE will connect to the network, e.g. similar with RRC Connected mode. Hence the detailed configuration will be received via the dedicated RRC signaling from the serving gNB. |
| LG | Yes with comment | Agree with the principle when the remote UE is in coverage. However, we need to consider whether the same principle can be applied or not when the remote UE is out of coverage. |
| Fraunhofer | Yes |  |

## Security aspects

In case of L2 based UE-to-Network Relay, the PDCP layer terminates at both Remote UE and gNB for a particular relaying radio bearer. The Security (confidentiality and integrity protection) is enforced at the PDCP layer between the endpoints at the Remote UE and the gNB [2] [23]. The PDCP traffic is relayed securely over two links, one between the Remote UE and the UE-to-Network Relay UE and the other between the UE-to-Network Relay UE to the gNB without exposing any of the Remote UE's plaintext data to the UE-to-Network Relay. [5] indicated that SA3 is going to study security and privacy aspects of UE-to-Network relay and security aspects of UE-to-UE relay. The relay architecture e.g. Layer-2 relay may also affect the SA3 work. RAN2 should await the progress in SA2 and SA3 before further discussion on security issues.

As a high level description for the security aspects for L2 relaying, the end-to-end Security (confidentiality and integrity protection) is enforced at the PDCP layer between the endpoints (i.e. between Remote UE and gNB for UE-to-Network Relay and between two Remote UEs for UE-to-UE Relay), and then there is no data exposure. RAN2 can attempt to agree this high level description.

Meanwhile, we recognize that SA3 needs to have input into the security aspects, but PDCP functionality is in RAN2’s expertise and we all know that security is terminated between the PDCP entities. So it seems reasonable to capture the basic information that end-to-end PDCP means end-to-end security, and we can incorporate further information from SA3 on the details when we receive it.

**Question 6: Do you agree to capture “The end-to-end security (confidentiality and integrity protection) is enforced at the PDCP layer between the endpoints and then there is no data exposure for L2 relaying.” Into the TR? If not, please give the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | See comments | We agree that the principle of the sentence is correct. However, we don’t think it is crystal clear. We have below 3 questions for clarification:  1. Who are “the endpoints”?  2. For "no data exposure for L2 relaying”, is it “L2 UE-to-NW relay” or “L2 UE-to-UE relay”, or both?  3. For "no data exposure for L2 relaying”, exposure to whom? |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Yes but | We agree in principle with the content of the question, but we think that SA3 needs to be consulted before to include in the TR something that may ne not correct.  We may need to send an LS to SA3. |
| Huawei | Yes | The content only addresses L2 relay case, which only the states legacy/current situation. So, we see no need to ask SA3 on the L2 relay, because this description is just based on the truth.  Some wording updates can be considered to address the concerns from QC.  **“For UE-to-NW relay, the end-to-end security (confidentiality and integrity protection) is enforced at the PDCP layer between the remote UE and gNB and then there is no data exposure to relay UE for L2 relaying.”**  **“For UE-to-UE relay, the end-to-end security (confidentiality and integrity protection) is enforced at the PDCP layer between the remote UEs and then there is no data exposure to relay UE for L2 relaying.”**  Anyway, we think the wording from rapporteur is already clear enough. |
| CATT | See comments | Regarding to the end-to-end security between remote UE PDCP and gNB PDCP, we think it had better send LS to SA3 for confirmation the following questions before we capture anything in the TR：  Question 1: Whether the current security mechanism on Uu link between the remote UE and gNB can be re-used for layer-2 UE-to-network‎ relay?  Question 2 : Besides the current security mechanism on Uu link, whether it is necessary to have other security mechanisms or not for layer-2 UE-to-network‎ relay? |
| Apple | Yes |  |
| Sony | Yes |  |
| ZTE | Yes | Agree with Qualcomm, the description shall be more clearly. |
| Convida | Yes | Yes with same comment as Ericsson above but can discuss this further in RAN2. Off course our view is we should agree to this and then share our agreement with SA3 to ensure they have no issue with it. |
| Interdigital | Yes |  |
| Intel | Yes in principle | In line with SID, “The study shall take into account of further input from SA WGs”, we suggest adding a note to get confirmation from SA3 and elaborate what end points refer to and for each case (U2N and U2U) |
| Futurewei | Yes | Huawei’s wording should help address Qualcomm’s comments. |
| Lenovo&MM | Yes |  |
| Fujitsu | Yes |  |
| Samsung | Yes but… | Regardless of RAN-level security, we think that the security requirements and principle should be confirmed by SA3, especially as we are not sure about the meaning surrounding the ‘exposure’? |
| Nokia | Yes, in princible |  |
| vivo | Yes |  |
| LG | Yes | We may need to confirm from SA3 via LS. |
| Fraunhofer | Yes |  |

## DL reachability and Paging for UE-to-NW relay

[7], [11], [14], [17], [29] and [42] discuss the DL reachability for the remote UE. [7], [17] and [42] suggests to use the conclusion of feD2D study as the baseline of paging monitoring. [14] proposes enhancement based on PO based monitoring. [29] suggests to differ the cases and the mechanism can be discussed case by case.

It is suggested that the Option 2 as studied in TR36.746 for FeD2D paging is selected as the baseline paging relaying solution for L2 based UE-to-Network relaying case. This means Relay UE monitors the Remote UE's PO in addition to its own PO. It also means there is some Relay UE-Remote UE association stored by the network. RAN2 is suggested to confirm this work assumption to avoid unnecessary debate during the study. It should be noted that the discussion on the RRC states within the email discussion on requirements and scenarios may be an input for this issue.

**Question 7: Do you agree that the Option 2 as studied in TR36.746 for FeD2D paging is selected as the baseline paging relaying solution for L2 based UE-to-Network relaying case (i.e. Relay UE monitors the Remote UE's PO in addition to its own PO.)? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes | Maybe some clarifications are needed:   * Whether in-coverage remote UE can receive paging via relay forwarding * How is it relayed? e.g. via groupcasting, or a container over PC5, or will it be placed into PC5 messages with new formats to be defined. * Whether RAN or CN paging are supported is needed. We assume that FeD2D solution in TR36.746 is only for CN paging because INACTIVE is not supported in LTE. |
| OPPO | Yes |  |
| Xiaomi |  | This is related to whether remote UE is allowed to be in IDLE or INACTIVE from gNB point of view. If remote UE is only allowed to be in CONNECTED, paging relay is not necessary. Note there are companies suggest remote UE stay in connected after relay connection establishment. |
| Ericsson (Tony) | Yes | We are fine to consider Option 2 in TR 36.746 as baseline, but the details and the changes needed should be further studied in this SI. |
| Huawei | Yes | Details can be studied in WI phase (or SI phase only if time allowed). |
| CATT | Yes |  |
| Apple | Yes | Details raised by Qualcomm can be discussed in WI. We think Option 2 can be used for both RAN paging and CN paging. |
| Sony | Yes |  |
| ZTE | Yes |  |
| Convida | Yes |  |
| Interdigital | Yes |  |
| Intel | Yes (with comment) | We are ok to consider it but it is to be noted that in FeD2D it was clearly applicable because the Remote UE and Relay UE had a “linked” relationship and there was a power saving requirement for Remote UE (which may not be exactly the same for this SI). So, we think it should be further discussed in RAN2 |
| Futurewei | Yes | This is of lower priority, and details can be deferred to WI phase. |
| Lenovo&MM | Yes | That means at least idle state for the remote UE is supported. Otherwise, the paging message is not needed for the remote UE. |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes |  |
| vivo | Yes | We agree that Option 2 in TR36.746 can be baseline. But the details are FFS, e.g. whether PC5 RRC exists or not, remote UE’s RRC state and relay UE’s RRC state, how to trigger and interact for Paging forwarding and so on. |
| LG | Yes with comment | We agree that option 2 paging in TR 36.746(FeD2D) is reused as a baseline. Also, RAN-paging delivery might need to be considered because there was no consideration of INACTIVE status in FeD2D.  SA2 had some concerns about relaying paging at the previous FeD2D times. So, we need to monitor SA2 meeting related to the paging operation before any decision in this SI. |
| Fraunhofer | Yes |  |

## System information reception for remote UE (UE-to-NW relay)

[7], [11], [14], [17], [29] and [42] discuss the System information delivery and forwarding to Remote UE. In rapporteur’s understanding, the system information reception mechanism as studied by TR36.746 for FeD2D can be reused. This means the Relay UE supports relaying of system information for its linked Remote Ues [17]. However, which SIBs are relayed can be discussed at normative phase.RAN2 is suggested to confirm this.

**Question 8a: Do you agree that the system information reception mechanism as studied by TR36.746 for FeD2D can be reused for L2 UE to Network Relaying (i.e. Relay UE supports relaying of system information for its linked Remote Ues)? If not, please give your alternative solution and the reason.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| MediaTek | Yes |  |
| Qualcomm | Yes | Maybe some clarifications are needed:   * Whether in-coverage remote UE can receive SIB via relay forwarding * What type of SIB it needs to relay? E.g. common SIB1, or dedicated SIB12 * How is it relayed? E.g. via groupcasting, or a container over PC5, or will it be placed into PC5 messages with new formats to be defined. |
| OPPO |  | It is OK to support it, but due to the unclear wording of the Question, it is hard to judge the intention of the rapporteur, e.g., whether it is to copy the whole section of 5.1.2.3, which is apparently not feasible since it is addressed for LTE..  And for “**(i.e. Relay UE supports relaying of system information for its linked Remote Ues)**”, does it mean that SI-forwarding is only for “linked” remote UE? |
| Xiaomi | Yes |  |
| Ericsson (Tony) | Partially | We believe that relay for all system information message(s) is not efficient for the relay/remote UE and this is because the remote UE may need also some of the information included in the SIB(s).  Since the relay UE needs to decode anyway the SIB(s) broadcasted by the network, a more efficient (from signaling and packet size) solution would be that the relay UE just send to the remote UE the necessary information via dedicated PC5-RRC signaling within new Ies.  Keep in mind that forwarding of the system information by the relay UE implies that we do need to support SIB segmentation also over PC5. |
| Huawei | Yes | To address the concern from other companies, we propose the following wording:  “Relay UE supports relaying of **essential** system information for its linked Remote Ues **via PC5-RRC signaling.** **FFS on which system information is considered as essential for Remote Ues.** “ |
| CATT | Yes |  |
| Apple | Yes with comments | While it is OK to support forwarding SI via PC5-RRC. But detailed mechanisms of PC5-RRC signaling design can be discussed in WI stage.  I think it is also necessary to discuss if OOC remote UE need any essential SI information before it is “linked” to a relay UE. |
| Sony | Yes |  |
| ZTE | Yes | We agree the baseline that the relay UE supports relaying of system information ONLY for its linked remote UEs. But how does the relay UE forwards the/what system information needs further discussion. |
| Convida |  | This requires more discussion. Off course, we should use the mechanism studied in TR 36.746 as a starting point, but it is not clear at this point without further discussion in RAN2 if the mechanism as designed for LTE should be re-used exactly as is for NR. For example some of the questions raised by OPPO or Ericsson, are example of questions we can discuss further. Additionally, it is not clear if the work in the study on enhancement of RAN slicing for example slice based cell reselection, will have any impact here. And therefore need to be considered. |
| Interdigital | Yes | As a baseline, we can assume the FeD2D approach (which is summarized in the wording from Huawei) and then we can further study whether SI should be forwarded also to UEs which are not “linked”. |
| Intel | Yes | Same comments as in the question above |
| Futurewei | Yes | This is of lower priority, and details can be deferred to WI phase. |
| Lenovo&MM | Yes | Some questions need to be answered to understand the intent of the question:   1. Is it only about SIs relating to Rel. 17 sidelink? 2. Does it also encompass Re. 16 V2X related SI? 3. SI other than the above? 4. RRC state of a remote UE (e.g. Idle, OOC) seeking, requesting SI?   On-demand SI acquisition also intended for the remote UE? |
| Fujitsu | Yes |  |
| Samsung | Yes |  |
| Nokia | Partially | Agree with Ericsson |
| vivo | Yes | SIB delivery is needed for OOC remote UE. But details are FFS, e.g. whether PC5 RRC exists or not, remote UE’s RRC state and relay UE’s RRC state, how to trigger and interact for SIB delivery, SIB delivery via PC5 unicast or PC5 groupcast/broadcast, the contents of delivered SIB(s) and on demand SI issue and so on. |
| LG | Yes | Remote UE can receive system information directly (via Uu link) or indirectly (via relay UE) when the remote UE is in coverage. However, if the remote UE is out of coverage, the remote UE cannot receive system information directly using Uu link. So, in that case, the relay UE has to relay the system information to the remote UE.  We assume the relay UE doesn’t need to know whether the remote UE is in coverage or not. So, we believe that the relay UE always has to relay the system information to the linked remote UE without considering the remote UE is in coverage or not. |
| Fraunhofer | Yes | We think that relaying system information to remote UE should be supported by relay UE especially considering an out-of-coverage remote UE. |

The support of on-demand SI delivery is proposed in some of the papers [7] [14] [29] [42].

From on demand SI perspective, it is not good way to let the remote UE go through the legacy Msg1/Msg3-based procedure, as it cannot be simply forwarded. RAN2 needs to discuss the handling over PC5 to support RRC Idle mode based on demand SI delivery for Remote UE.

In NR Rel-16, the on-demand system information transmission is enhanced to support RRC-Connected mode UE also. There may be scenarios where Relay UE is RRC connected, and Remote UE is also RRC connected. So then there may be a case that On-demand SI transmission needs to be supported between Remote UE and network. The necessary PC5 RRC may need to be enhanced in order to enable the relaying operation at Relay UE for the On-demand SI transmission.

RAN2 is suggested to confirm the need to support the On-demand SI transmission for both RRC Idle and RRC connected Remote UEs.

**Question 8b: Which option do you prefer with regard to the support on-demand SI delivery for Remote UE? Please give the reason for your choice.**

**Option1: Support on-demand SI delivery for Remote Ues in RRC Idle/Inactive**

**Option2: Support on-demand SI delivery for Remote Ues in RRC Connected**

**Option3: Support on-demand SI delivery for Remote Ues in RRC Idle/Inactive and RRC Connected**

**Option4: Do not support on-demand SI delivery for Remote UE**

**Option5: Re-use legacy on-demand SI delivery for the Relay UE (in IDLE/INACTIVE/CONNECTED)**

|  |  |  |
| --- | --- | --- |
| Company | Preferred Option | Comments |
| MediaTek | Option 3 | We need to support all scenarios for on-demand SI delivery based on the discussion for on-demand SI at NR Rel-15/Rel-16. PC5 based SIB forwarding may need be supported to enable on-demand SI from the network to the UE. |
| Qualcomm | See comments | We think we first need to get the use case and scenario clarified. We are open to discuss when on-demand SI delivery is required via relay.  In addition, since we have discussed RRC state of relay, then one clarification may be needed what is valid RRC state combination between remote UE and relay, e.g.:   * Relay in CONNECTED while remote IDLE * Relay in IDLE while remote CONNECTED * Both Relay and remote in CONNECTED * Both Relay and remote in IDLE |
| OPPO | 3 | Yet we fail to understand the connection between the justification text and question here.  For idle UE, the sending of rrcSystemInfoRequest is not different from other SRB0 UL message, andfor connected UE, the sending of dedicatedSIBRequest is not different from other SRB1 UL message, and thus there could be no extra enhancement due to supporting this. |
| Xiaomi | Option 4 | First, we should identify which SIB is needed for remote UE.  We think only SIB1, 6, 7, 8 are needed for remote UE. SIB 1 is always broadcast. SIB 6, 7, 8 should be broadcast if there is CMAS or ETWS notification. Therefore, the need of SI request is not justified. |
| Ericsson (Tony) | Option 3 and Option 5 | Not sure why the INACTIVE state has been left out.  Relay UE, that is in coverage, already support legacy on-demand SI/SIB request and thus we can re-use this for free. There is no benefit to allow the remote UE to request SI/SIBs on demand as this it may be out-of-coverage. |
| Huawei | Option 3 | We don’t need to discuss option 5 for relay UE, which is the legacy operation.  To clarify option 3 as  “Support on-demand SI delivery for Remote Ues in RRC Idle/Inactive and RRC Connected **by the E2E RRC connection via the relay UE**”  The intention is mainly for remote UE connecting the NW by in-direct connection via relay. If remote UE is OOC, it can connect to relay UE and then to the NW to send the RRC message. So, we just reuse the legacy RRC procedure to support the remote UE’s on-demand SI via relay UE. |
| CATT | Option3 | Agree with OPPO |
| Apple | Option 3 (excluding Msg-1 based on-demand SI retrieval) | I think on demand SI for both CONNECTED and IDLE/INACTIVE mechanisms can be supported. However, for remote UE support IDLE/INACTIVE on-demand SI mechanisms, Msg1-based solution cannot be used. |
| Sony | Option 3 |  |
| ZTE | Option 3 | On-demand SI transmission for both RRC Idle/inactive and RRC connected Remote UEs can be supported. But whether the inactive state is necessary for remote UE may be further discussed. |
| Convida | Option 3 | Support on-demand SI delivery for Remote UEs in RRC Idle/Inactive and RRC Connected.  Also the case of OoC remote UE should be considered i.e. delivery of on-demand SI to OoC UE should be supported. |
| Interdigital | Option 3 | We agree with OPPO and Apple, and we think we should exclude MSG1-based solution, at least initially. |
| Intel | Option 3 | As Huawei mentioned, we are not sure why Option 5 is added here since the question was related to how remote UE acquires the SIB. |
| Futurewei | Option 3 |  |
| Lenovo&MM | Option3 | on-demand SI delivery is needed for the remote UE in idle,inactive and connected state regardless of OOC or IC remote UE. |
| Samsung | Option 3 |  |
| Nokia | Option 3(5) |  |
| vivo | Option 3 | In our understanding, for a remote UE of RRC Idle/Inactive without connection to relay UE, it can acquire on-demand SI via legacy mechanism.  For a remote UE of RRC connected mode with connection to a relay UE, it can trigger and acquire on-demand SI via its own Uu SRB1 from network. |
| LG | Option 4 | We assume essential SIB will be relayed from relay UE to all linked remote UEs commonly. Essential SIB is some SIBs to support relay operation. For example, the essential SIB can be considered MIB(SFN, bandwidth), SIB1(PLMN, cell information), SIB2(access barring information), and sidelink related SIB(e.g., SIB 18/19 or new SIBs). And also, relay UE can optionally relay other SIBs(e.g., SIB10,11, 12, 13, 14, 15) depending on the linked remote UEs. If linked remote UE requests some other system information not to be related to relay operation, the relay UE doesn’t need to support that request. So, we think there is no system information to be requested on-demand from remote UE to relay UE. If there is any system information to be on-demanded from remote UE, we can discuss that. |
| Fraunhofer | Option 3 |  |

## Other issues

There may be additional issues that need to be discussed to describe the L2 relaying from high level perspective.

**Question 9: Please give the explanation of any additional issues to describe the L2 relaying from high level perspective.**

|  |  |  |
| --- | --- | --- |
| Company | Agree/Disagree | Comments |
| Ericsson (Tony) | Remote UE out-of-coverage | It looks like the assumption of the email discussion rapporteur is that the remote UE is “always” in coverage.  However, would should not limit the analysis only to this use case at this stage. For the sake of the study item, we have to study both situations on when the remote UE may be in coverage or out-of-coverage.  We kindly ask, then, to include the out-of-coverage remote UE use cases in the proposed questions.  [Huawei]: If remote UE is OOC, remote UE will use the L2 relay architecture via a relay UE. Then, remote UE is under NW control via SIB or dedicated signalling. So, no particular issue for OOC in L2 relay, but the issue exists in L3 relay if remote UE is in OOC. |
| Ericsson (Tony) | Exchanging of capability | In situations when the remote UE is out-of-coverage, the remote UE may not be able to exchange its capability with the gNB/UE.  In this case, the relay UE should do it. |
| Ericsson (Tony) | RRC states of the relay UE and remote UE | Out assumption is that the relay UE and remote UE may have different RRC states, but we should limit the combination of those because some of them may not be practical. In the following table to explain what our idea of the supported RRC state combinations is:   |  |  |  | | --- | --- | --- | | **RL UE state** | **RM UE state** | **Validity** | | CONNECTED | CONNECTED | Valid | | CONNECTED | INACTIVE | Valid | | CONNECTED | IDLE | Valid | | INACTIVE | CONNECTED | Invalid | | INACTIVE | INACTIVE | Valid | | INACTIVE | IDLE | Valid | | IDLE | CONNECTED | Invalid | | IDLE | INACTIVE | Valid | | IDLE | IDLE | Valid | |
| Ericsson (Tony) | Inactivity monitoring | How to handle the inactivity monitoring of the relay/remote UE is not clear yet. Our assumption is that the presence of a relay path should be taken into account when performing inactivity monitoring at the NG-RAN or UE for the relay UE. |
| Ericsson (Tony) | Service continuity | Not sure this need to be addressed here, but is probably among the most important items to be investigated in this study item. |
| Apple | RRC state issue | This is very important and needs to be captured in TP |
| Apple | Whether and how to support SI forwarding for remote UE not “linked” yet | This is also a high-level issue needs to be resolved in SI stage. |
| Convida | Agree that the issues raised by Ericsson above should be discussed one way of the other if not here. |  |
| Interdigital | Note on RRC state discussion | Perhaps RRC state discussion need not be repeated, given it is discussed in [603]. |
| Intel | QoS aspects | Impact of supporting end-to-end QoS needs to be studied as also discussed in [23] (network control) |
| Lenovo&MM | CN registration | If idle state is supported for the remote UE, that means CN registration is expected for the idle remote UE. There is no end-to-end RRC connection between the idle remote UE and gNB. Therefore, the PC5 interface should be involved for the CN registration purpose. |
| LG | Group mobility | In FeD2D, group mobility was one of the hot issues. We need to address whether to handle group mobility in this SI. |

# Rapporteur’s summary

This document promulgated the following proposals with a companion TP:

# References

[1]R2-2006572 Architecture Options for Sidelink Relay MediaTek Inc.

[2]R2-2006555 UE-to-network relay architecture and procedures Qualcomm Incorporated

[3]R2-2007100 Discussion on User Plane mechanisms for Layer 2 Relay Apple

[4]R2-2008019 Relaying mechanism for NR sidelink LG Electronics Inc.

[5]R2-2007181 Overview of Layer-2 and Layer-3 sidelink relay mechanisms Sony

[6]R2-2007460 Protocol stack design for L2 relay Lenovo, Motorola Mobility

[7]R2-2008047 Study aspects of UE-to-Network relay and solutions for L2 relay Huawei, HiSilicon

[8]R2-2006604 Protocol stack and CP procedure for SL relay OPPO

[9]R2-2006867 Mechanisms and Characteristics in NR Sidelink Relaying Fujitsu

[10]R2-2006962 Mechanisms for supporting L2-based Sidelink Relays AT&T

[11]R2-2007041 Protocol stack and service continuity for L2 and L3 relay vivo

[12]R2-2007044 Discusssion on architecture for NR sidelink relay Spreadtrum Communications

[13]R2-2007100 Discussion on User Plane mechanisms for Layer 2 Relay Apple

[14]R2-2007101 Discussion on Control Plane mechanisms for Layer 2 Relay Apple

[15]R2-2006722 Protocol Stack and Connection Setup Procedure of Sidelink Relay Futurewei

[16]R2-2006737 Discussion on NR SL Relay Architecture ZTE Corporation, Sanechips

[17]R2-2006759 Discussion and TP on UE to NW Relay Based on L2 Relay Architecture InterDigital

[18]R2-2006760 Discussion and TP on UE to UE Relay Based on L2 Relay Architecture InterDigital

[19]R2-2006855 Considerations for L3 UE-to-Network Relays Nokia, Nokia Shanghai Bell

[20]R2-2007203 L3 vs L2 relaying Samsung Electronics GmbH

[21]R2-2007292 Considerations on L2 and L3 SL relay protocol design Ericsson

[22]R2-2006611 L2/L3 UE-to-NW Relay Comparison CATT

[23]R2-2006718 Characteristics of L2 and L3 based Sidelink relaying Intel Corporation

[24]R2-2006843 View on L2/L3 SL relay ITL

[25]R2-2006557 Discussion on NR sidelink relay selection and reselection Qualcomm Incorporated

[26]R2-2006770 Discussion on SL relay (re)selection and authorization OPPO

[27]R2-2006861 NR Sidelink Relay (Re-)Selection Criterion and Procedure Fraunhofer IIS, Fraunhofer HH

[28]R2-2006639 L2 vs L3 - Relay (re-)Selection, Quality of Service (QoS) Fraunhofer HHI, Fraunhofer IIS

[29]R2-2006571 RRC States for Relaying MediaTek Inc.

[30]R2-2007462 RRC state and CN registration of the remote UE Lenovo, Motorola Mobility

[31]R2-2008048 Service continuity for L2 UE-to-Network relay Huawei, HiSilicon

[32]R2-2008066 Discussion on service continuity from Uu to relay Xiaomi communications

[33]R2-2006641 L2 vs L3 Relay/Remote UE Authorization, Service Continuity Fraunhofer HHI, Fraunhofer IIS

[34]R2-2006723 Service Continuity with Sidelink Relay Futurewei

[35]R2-2007461 Relayed connection management Lenovo, Motorola Mobility

[36]R2-2007608 Impact on user plane protocol stack/control plane procedure for Sidelink Relay Intel

[37]R2-2007816 Considerations on UE-to-NW Relay ETRI

[38]R2-2008043 Consideration of Relay characteristics LG Electronics Inc.

[39]R2-2007040 Selection/Authorization and Security for L2 and L3 relay vivo

[40]R2-2006724 QoS Control with Sidelink Relay Futurewei

[41]R2-2007099 Discussion on NR Sidelink Relay Scenarios Apple, Convida Wireless

[42]R2-2006610 User and Control Plane Procedures for L2 UE-to-NW Relay CATT

# TP on L2 relay mechanism

TP to be developed:

# Annex for company contacts

Company contacts for this discussion is captured in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Contact | Email of Contact |
| MediaTek | Xuelong Wang | Xuelong.Wang@ MediaTek.com |
| Ericsson | Antonino Orsino | antonino.orsino@ericsson.com |
| Qualcomm | Peng Cheng | Peng Cheng <chengp@QTI.QUALCOMM.COM> |
| OPPO | Qianxi Lu | Qianxi Lu <qianxi.lu@OPPO.COM> |
| Huawei | Yulong Shi | shiyulong5@huawei.com |
| Xiaomi | Xing Yang | yangxing1@xiaomi.com |
| CATT | Hao Xu | xuhao@catt.cn |
| Apple | Zhibin Wu | Zhibin.Wu@apple.com |
| Sony | Vivek Sharma | Vivek.sharma@sony.com |
| Futurewei | Hao Bi | Hao.bi@huawei.com |
| Samsung | Milos Tesanovic | m.tesanovic@samsung.com |
| vivo | Jing Liang | [liangjing@vivo.com](mailto:liangjing@vivo.com) |
|  |  |  |