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

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

Agenda Item: 8.7.2

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

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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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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]:

* 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**

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| 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 |
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## 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)**

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| 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. |
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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 between two Remote UEs for L2 UE-to-UE relaying (i.e. between Relay UE and receiving Remote UE)? If not, please give your alternative solution and the reason.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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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)**

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| 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.  |
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## 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**

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

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

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| 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.  |
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## 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)

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| 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 |
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**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)

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| 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 |
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## 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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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There is a discussion in [1] on when to configure the SLRB configuration to Remote UE out of coverage to help them to establish the unicast link channel with Relay UE. [1] suggests that SLRB configuration is pre-configured in the Remote UE for each Relay Service in order to help remote UE to setup the PC5 unicast link with a relay UE before relaying Control plane data for L2 remote UE. [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. [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 5b: Do you agree that for Uu SRB0 of the Remote UE, related parameters on PC5 (e.g. RLC channel) and Uu link are predefined by specification? If not, please give your alternative solution and the reason.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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**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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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## 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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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## DL reachability and Paging for UE-to-NW relay

[7], [11] [14] [17] and [29] discuss the DL reachability for the remote UE. [7] and [17] 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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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## System information reception for remote UE (UE-to-NW relay)

[7], [11], [14], [17] and [29] 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.**

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| Company | Yes/No | Comments |
| MediaTek | Yes |  |
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The support of on-demand SI delivery is proposed in some of the papers [7] [14] [29].

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**

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

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

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

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| 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.  |
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## 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.**

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# 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

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# TP on L2 relay mechanism

TP to be developed: