**3GPP TSG RAN WG2 Meeting #111-e R2-200xxxx
E-Conference, 17th – 28th August 2020**

**Agenda item: 8.7.3**

**Source: Qualcomm Incorporated**

**Title: Summary of offline discussion [604][Relay] L3 relay protocol stacks (Qualcomm)**

**WID/SID: FS\_NR\_SL\_relay – Release 17**

**Document for: Discussion and Decision**

# Introduction

This is discussion document for below offline discussion of RAN2#111-e:

* [AT111-e][604][Relay] L3 relay protocol stacks (Qualcomm)

      Scope: Discuss and document the proposed L3 relay design(s), focussing on general mechanisms of L3 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

As mentioned in “Scope”, we will discuss the following aspects:

* User plane protocol stack of L3 UE-to-NW relay
* Control plane protocol stack of L3 UE-to-NW relay, and the related control plane procedures:
	+ Authentication
	+ PC5 link establishment procedure
	+ QoS for relaying functionality
	+ Security of relayed connection
	+ Service continuity
* Protocol stack of L3 UE-to-UE relay

Meanwhile, rapporteur have below clarifications on the offline discussion scoping:

* Discovery and relay (re)selection are not included in discussion scoping
* Candidate solutions are from SA2 TR 23.752 [1] and companies’ contributions [3-28].
* On UE-to-UE relay: although few companies discussed its L3 relay protocol stacks, note that following Note of SID

“NOTE 2: It is assumed that UE-to-network relay and UE-to-UE relay use the same relaying solution” [2].

Rapporteur tried to progress with assumption the similar protocol stack of L3 UE-to-Network relay can be reused for L3 UE-to-UE relay.

Finally, because the outcome may include an agreeable TP, rapporteur would like to divide into 2 phases:

* Phase 1: collect companies’ view, by Friday 2020-08-21 23:50 UTC
* Phase 2: rapporteur will share summary report and TP based on input of phase 1 for review, by Monday 2020-08-24 12:00 UTC

# Discussion

Below discussion, please note NOTE1 of SID [2]:

*“NOTE 1: The study shall take into account of further input from SA WGs, e.g., SA2 and SA3, for the bullets above (if applicable).”*

Thus, for each discussion, we will first provide inputs from SA2 and SA3 as starting point.

## User plane protocol stack of L3 UE-to-NW relay

SA2 agreed on the L3 user plane protocol stack (shown in Figure 1 below) in TR 23.752 [1] clause 6.6:



**Figure.1: User plane protocol stack for L3 UE-to-Network Relay in clause 6.6 of TR 23.752**

Multiple companies discussed this topic [3][4][5][13][16][18][22][23][28]. Their opinions can be summarized below:

* Alt-1: Follow Figure 1 in clause 6.6 of TR 23.752 ([3][4][5][13][16][18][22][23][28])
	+ According to them, there are no AS impacts expected for supporting this user plane protocol stack for L3 relays and RAN2 can adopt this protocol stack as is for L3 relay.
* Alt-2: With adaptation layer above PDU layer ([9]), as illustrated in Figure. 2.
	+ According to [9], this reflects the intended L3 UE relay operation, in which 5G QoS flow is first mapped to PC5 QoS flow for sidelink transmission; then the PC5 QoS flow is mapped to 5G QoS flow of the relay UE for transmission over Uu interface; finally the 5G QoS flow of the relay UE is mapped back to the remote UE’s 5G QoS flow at UPF. .



**Figure.2: User plane protocol stack for L3 UE-to-NW Relay proposed in [9]**

Companies are invited to share their preference for these alternatives:

**Q1: Which alternatives do you prefer for user plane protocol stack of L3 UE-to-NW Relay?**

* **Alt-1: Figure 1 (in clause 6.6 of TR 23.752)**
* **Alt-2: Figure 2 (proposed in [9])**

|  |  |  |
| --- | --- | --- |
| Company | Preference (Alt-1/Alt-2) | Comments |
| MediaTek | Alt-1 | We see no reason to deviate the protocol stack as discussed at SA2, as L3 relay is mainly in SA2 expertise.  |
| Futurewei | Alt-2 | It makes clear that 5G QoS flow of the remote UE needs to be mapped to 1) PC5 QoS flow between the remote UE and the relay UE and 2) 5G QoS flow of the relay UE. These three types of QoS flows belong to 3 different PDU sessions, the remote UE’s PDU session, the PC5 session between the remote UE and the relay UE, and the relay UE’s PDU session, respectively. |
| Xiaomi | Alt-1 | Any L3 solution should be confirmed by SA2 first. But we wonder whether this selection should be made in RAN2. |
| OPPO |  | Apparently the selection of L3 relay protocol it is up to SA2, e.g., one has to consider the other alternative of N3IWF.On the other hand, RAN2 can try to have common understanding of the assumed protocol stack based on which to discuss RAN2 aspect – so the question is whether the alternatives of L3 relay stacks in SA2 TR makes a difference to RAN2-related work? |
| Ericsson (Tony) | Alt-1 | Alt-1 is aligned with SA2 and we see no reason to deviate from this. |
| Qualcomm | Alt-1  | @Xiaomi: the figure of Alt-1 is already captured in SA2 TR 23.752. I am not sure why you think SA2 needs to confirm something in their TR?@OPPO: since this protocol stack is specified in SA2 TR, why can’t RAN2 study its RAN impact first? Our consideration is that L3 relay protocol stack with or without N3IWF has only SA2 impact and no RAN2 impact. Thus, we would like to first capture L3 relay protocol stack without N3IWF and study its RAN2 impact. After that (maybe next meeting), we can also capture L3 relay protocol stack with N3IWF, and companies can quickly confirm no extra RAN2 impact on top of this one. @Futurewei: we understand your intention. However, adaptation layer is over PDU layer. And QoS flow is mapped between remote and relay in your proposal. Then, I am not sure whether it is within RAN2 scoping?  |
| CATT | Alt-1 or N3IWF | Agree with OPPO, the L3 relay architecture should be decided by SA2. |
| Fraunhofer | Alt-1 | It is unclear to us why the requirements of the application would need to be translated to the 5G QoS flows first rather than to the PC5 QoS flows directly. From our understanding, applications would be designed for both sidelink and Uu based protocol stack. |
| Huawei |  | We share the same view with OPPO and CATT that the L3 protocol stack should be decided by SA2. And what RAN2 can do is only to analyze the RAN2 impact.And our understanding is from RAN2’s point view, the AS part of Alt-1/Alt-2/N3IWF are the same (at least for AS protocol stack).Regarding QoS aspect, we are not sure how the 5G QoS flow works for L3 relay, given that the remote UE may transmit 5G QoS flow/PDU session via PC5 to relay UE.  |
| vivo | Alt-1 | Take Alt-1 as the basic L3 Relay architecture. |
| ZTE | Alt-1 | For alt-2, we think mapping between QoS flows and PDU session is handled by core network, which is out of RAN2’s scope. And for protocol stack design, PDU session shall not be included in the protocwordol as one layer. As described in 23.501, PDU layer is corresponds to the PDU carried between the UE and the DN over the PDU Session.When the PDU Session Type is IPv4 or IPv6 or IPv4v6, it corresponds to IPv4 packets or IPv6 packets or both of them; When the PDU Session Type is Ethernet, it corresponds to Ethernet frames. In other words, PDU layer is IP layer or Ethernet layer. In consequence, it doesn’t make sense that we put QoS flow mapping layer, i.e. adaptation layer , above the PDU layer. |
| Lenovo | Alt-1 | SA2 made already agreement on L3 protocol stack.  |
| Nokia |  | The L3 protocol stack is in the scope of SA2. Alt-1 is an acceptable starting point with the disclaimer that the solution with N3IWF should also be captured. (Minimal or no RAN impacts are expected between the L3 variants.) It might be better not to capture anything before SA2 concludes this issue. |
| Apple | Alt-1 or N3IWF | TO be finally decided by SA2 |

## Control plane protocol stack of L3 UE-to-NW relay

Because control plane protocol stack is related to AS control plane procedures. Thus, rapporteur suggest to first study control plane procedure of L3 UE-to-NW relay, and then discuss control plane protocol stack based on the inputs.

### Control plane procedure

Figure 3 shows the relay connection setup procedures agreed for L3 UE-to-network relay in SA2, in section 6.6 of TS 23.752 [1]. 

Figure.3: L3 UE-to-NW relay connection setup procedures

These procedures reuse the LTE ProSe and NR V2X procedures, and rapporteur think that basically the high-level procedures as proposed by SA2 are sufficient for L3 relay operation. Multiple companies discussed this topic [3][4][21], and it seems most of them agree the high-level procedure in Figure.3. Rapporteur would like to confirm whether companies have the common understanding.

**Q2: Do you agree to capture the high-level connection setup procedure of L3 UE-to-NW relay in Figure. 3 in TP?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes with but | We agree the overall procedure as shown in the figure for connection setup procedure of L3 UE-to-NW relay. But it is better for RAN2 to make a reference link to the section of SA2 which helps to capture any latest update from SA2 side. By the way, as can be seen, there is no AS layer procedure in the flow and then capturing the figure does not help to proceed L3 relay study at RAN2 side.  |
| Futurewei | No | NG-RAN is also involved in Step 3 to configure the sidelink DRB for relay. Figure 3 is too abstract to help document RAN UP/CP functionalities, lacking steps taken between the remote UE, the relay UE, and the serving gNB in the UE-to-Network relay connection setup procedure. |
| Xiaomi | Yes with comments | Generally, the solution is fine. But we think the relay selection should also be included in the procedure, which may have AS impact. |
| OPPO |  | We do not see the point to copy a figure from SA2 TR has no/little content for RAN into RAN TR..On the other hand, RAN2 can try to have common understanding of the assumed protocol stack based on which to discuss RAN2 aspect – so the question is whether the alternatives of L3 relay stacks in SA2 TR makes a difference to RAN2-related work? |
| Ericsson | Yes | However, we agree with MediaTek that a reference to the SA2 TR it would help to capture any latest update made by SA2.We are also fine to investigate the RAN2 impact in how the AS layer is impacted by this procedure, even if we do not see a strong change in legacy procedures. |
| Qualcomm | Yes | We agree with MediaTek that a reference to SA2 TR is helpful.Our consideration is that this figure is just a starting point for RAN2 to study L3 relay’s AS impacts. If we don’t even have a common understanding of baseline procedure, how can we discuss its AS impact on the fly? We do plan to study its AS impact, e.g. discovery and relay (re)selection will be included in this figure after their AS impacts are identified.@OPPO: we are still not sure why RAN2 need to jump to study the impact of protocol stack with N3IWF, before the study of the one without N3IWF is finished.  |
| CATT | Yes | This section should be appear in the TR, but the details can refer to SA2 spec. |
| Fraunhofer | Yes | Agree with QC, we can use this as a baseline and discuss aspects that impact the AS |
| Huawei |  | Agree with OPPO, there is no need to copy this SA2 figure in RAN2 TR, we can decide what RAN2 related CP procedures to be discussed/captured. |
| vivo | Yes | This Figure helps us to better understand the whole picture of how L3 based relaying works.  |
| ZTE | Yes | We also need to add more RAN2 related details below this figure in RAN2 TR. |
| Lenovo | Yes | We agree that the procedure captured in SA2 TR should be the starting point. However there is in our understanding not much benefit to copy it in TP. Reference to SA2 TR may be sufficient. |
| Nokia | Yes, but see comments | We should refer to SA2 TR on the details of the procedure. We should also capture the procedure for N3IWF solutions. (Minimal or no RAN impacts are expected between the L3 variants.) |
| Apple | Yes | Agree with MediaTek that can be refer to SA2 TR. We do not see any RAN2 impact for this procedure. |

Then, rapporteur think the following details of each step in Figure. 3 need further discussion:

* Relay / Remote UE authorization (corresponding to step 0)
* PC5 link establishment procedure (corresponding to step 3)
* QoS for relaying functionality (corresponding to relay PDU session establishment in step 3)
* Security of relayed connection
* Service continuity

#### Relay / Remote UE authorization

It is illustrated in step 0 of Figure. 3. In TR 23.752 [1], SA2 agreed to reuse PCF based service authorization and provisioning defined for NR V2X in TS 23.287 [29] for both L3 and L2 relays.

Multiple companies discussed this topic, and their views can be summarized as below:

* View 1: RAN2 follows SA2/SA3, i.e. no RAN2 impact expected ([3][8][13][14][28])
* View 2: RAN2 need further discussion:
	1. View 2-1: The authorization information stored in gNB is only introduced for relay and transparent to remote UE. In addition, the ignalling procedure will reuse the Rel-16 NR V2X sidelink authorization as baseline, e.g. in NG interface and Xn interface. [17]
	2. View 2-2: RAN study the potential impacts to the ignalling procedures of remote UE authorization (e.g. relay performs an additional authentication step before allowing the remote UE to access the application server). [7]

Rapporteur’s understanding is that this is a NAS procedure and there is no AS aspect to be further defined for this step. Meanwhile, Rapporteur also think the issues raised in View 2-2 have been studied in SA2 as solution#30 (separate authorization) and solution#35 (mutual authorization) in TR 23.752 [1]. Furthermore, it seems both solution#30 and solution#35 only need some N2 interface change, which is RAN3 scoping. Thus, to make progress, rapporteur suggest RAN2 to agree view 1.

**Q3: Do you agree that there is no RAN2 impacts expected for support of Relay/Remote UE authorization for L3 UE-to-NW relay in SI (i.e. RAN2 follows SA2/SA3 agreements)?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | Yes |  |
| Xiaomi | Yes |  |
| OPPO | Yes | We assume the rapporteur here asked for the authorization for communication while the discovery related part is handled in 606. |
| Ericsson | Yes |  |
| Qualcomm | Yes | @OPPO, No, we think it is in scoping of this email discussion. And we sent this discussion document before the discovery discussion 606. |
| CATT | Yes |  |
| Fraunhofer | Yes, with comment | We understand the views of the rapportuer. However, similar to OPPO, we were also under the similar assumption regarding the differentitation between authorization for discovery and authentication of a PDU session  |
| Huawei | Yes, with comment | We also understand this is a common issue for L3 and L2, so that it would be better to cover this in #606. |
| vivo | See comments | We are a little confused about tise question. In our understanding, no matter which view 1 or 2 is selected, the main work lies in SA2 and RAN3, not RAN2. A LS can be sent to SA2/RAN3 to inform our decision if we agree simply to follow other WG’s input. |
| ZTE | Yes |  |
| Lenovo | Yes | No RAN2 impact is foreseen here. |
| Nokia | Yes |  |
| Apple | Yes |  |

#### PC5 link establishment procedure

It is illustrated in left part of step 3 in Figure. 3. SA2 assumes that the remote UE user plane traffic is only sent to the selected relay UE. That is, use PC5 unicast communication for the L3 Remote UE traffic. Also, to support the PC5 unicast communication, SA2 agreed to reuse NR V2X PC5 unicast link establishment procedures for L3 relay as per the architecture recommendations in 5G ProSe SA2 TR [1]. Because NR V2X PC5 unicast link setup is based on PC5-S and PC5-RRC, Rapporteur think it can be reused in L3 UE-to-NW relay, which needs companies’ confirmation.

**Q4: Do you agree to reuse Rel-16 NR V2X PC5 unicast link establishment procedures based on PC5-S/PC-RRC to setup a secure unicast link between Remote UE and Relay UE before traffic relaying?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | Yes with comment | Rel-16 NR V2X PC5 unicast link establishment procedure can be reused for the sidelink connection with the control of gNB connected to the relay UE. |
| Xiaomi | Yes |  |
| OPPO | Yes with comment | Yet the part of PC5-S is still in SA2 scope, what RAN can assume would be the reusing of PC5-RRC procedures. |
| Ericsson | Yes | Legacy Rel-16 NR V2X PC5 unicast link establishment procedures can be the baseline in this case. |
| Qualcomm | Yes | We have same understanding as Ericsson. The intention is just to confirm the legacy procedure can be reused. In addition, we are not sure how PC5-RRC can be established if we don’t have PC5-S.  |
| CATT | Yes | But the PC5-S signaling content may be different, which depends on SA2 design. |
| Fraunhofer | Yes | Agree with Ericsson |
| Huawei | Yes |  |
| vivo | Yes, with comments | Agree with the intention to reuse legacy but we may wait for SA2 progress on the detailed PC5-S signaling procedure, e.g., merging of discovery and unicast link establishment procedures is still under discussion in SA2. |
| ZTE | Yes |  |
| Lenovo | Yes | Rel-16 NR V2X PC5 unicast link establishment procedures should be the baseline. |
| Nokia | Yes | We also think that Rel-16 NR V2X PC5 unicast link establishment should be the baseline. |
| Apple | Yes |  |

#### QoS for relaying functionality

It is related to the right part of step 3 in Figure. 3. L3 Relay UE forwards Remote UE’s traffic to CN using its own PDU session. SA2 agreed that QoS for relaying functionality reused Rel-16 V2X design with new PQIs in TR 23.752 [1], and E2E QoS support is specified in TR 23.752 [1]. As illustrated in Figure. 4, QoS is managed separately on the two hops, and need to be linked to achieve E2E QoS. Furthermore, as illustrated in solutions 6.24, and 6.25 from [1], because the relayed data would go over relay UE’s PDU session, the relay UE may perform appropriate mapping of PQI to 5QI by communicating with the SMF/PCF and also perform UE requested PDU session modification accordingly.



**Figure.4: QoS model of L3 UE-to-NW relay in TR 23.752**

Multiple companies discussed this topic [5][6][8][11][13][18], but it seems there is no clear summary on what SA2 agreed. Thus, Rapporteur would like to confirm whether people have same understanding, which can be starting point of QoS discussion in RAN2.

**Q5: For L3 UE-to-NW relay QoS support, do you agree RAN2 to follow below SA2 TR:**

1. **PC5 link reuses Rel-16 V2X design with new PQIs in TR 23.752**
2. **E2E QoS support is specified in TR 23.752 , where relay may perform appropriate mapping of PQI to 5QI by communicating with SMF/PCF and performs UE requested PDU session modification accordingly.**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes | Meanwhile, we think RAN2 needs to discuss the corresponding AS support to enforce the QoS mechanism as will be concluded by SA2.  |
| Futurewei | Yes | We understand a) and b) are captured in TR 23.752 as possible solutions for L3 UE-to-Network relay.We also think that AS involvement after b) to enforce the updated QoS profile should be discussed and documented. |
| Xiaomi | Yes |  |
| OPPO |  | We fail to understand the said “SA2 agreement”: there is no TR conclusion in SA2 TR yet.. so the a/b here are just alternatives on the table. Furthermore, for a), our understanding of the new PQI is it has nothing to do with the relay. |
| Ericsson  | Yes |  |
| Qualcomm | Yes | @OPPO: we changed “SA2 agreement” to “SA2 TR”. Our understanding is both a and b will be specified in SA2. Up to now, we are not aware any RAN2 contribution discussed AS support to enforce QoS. Let us discuss based on companies’ contribution. |
| CATT | Yes |  |
| Fraunhofer | Yes |  |
| Huawei |  | We understand the QoS framework is in SA2 scope, and RAN2 should focus on how to enforce the E2E QoS in RAN, e.g. the SLRB configuration and the bearer mapping. |
| vivo | Yes | We wait for SA2 progress for L3 QoS support. |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Nokia | Yes | The E2E QoS is in the scope of SA2. RAN2 should only investigate if any AS enhancements is needed to support the solution agreed in SA2 |
| Apple | Yes with comments | Not sure if new PQIs are really needed for PC5 link in L3 U2N relay. But agree this can be decided by SA2. |

Furthermore, companies provide the below proposals:

* [5] proposed that SMF/PCF is responsible for the end-to-end PDB splitting between the Uu link and PC5 link. The spitted PDB is indicated to relay to perform UE requested PDU session modification.
* [13] proposed for uplink data of remote UE, the bearer mapping can be realized by using uplink QoS rules of relay UE while the mapping between Uu traffic and PC5 traffic shall be considered for downlink data.
* [8] proposed to wait SA2 inputs on:
	1. Whether splitting of end-to-end QoS profile onto individual link PQI and 5QI
	2. Whether the PDB will be provided as end-to-end parameter or split using upper layer signalling.

Rapporteur understand all above proposals are being discussed in SA2, and RAN2 can leave them to SA2 decide. To make progress, rapporteur would like to confirm whether companies have the same understanding:

**Q6: For L3 UE-to-NW relay QoS support, do you agree it is left to SA2 to conclude:**

1. **Whether splitting of end-to-end QoS profile onto individual link PQI and 5QI**
2. **Whether the PDB will be provided as end-to-end parameter or split using upper layer signalling.**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | Yes | We should focus on the impacts of a) and b) on RAN. |
| Xiaomi | Yes |  |
| OPPO | Yes | Apparently it is SA2 scope. |
| Ericsson | No | It is beneficial to leave to gNB to perform PDB split, since gNB has better knowledge than CN. Generally, there is RAN2 aspect. CN provides the complete PDB without splitting to the gNB. gNB can perform the split considering radio channel quality of both links. |
| Qualcomm | Yes | We don’t think it has RAN2 impacts |
| CATT | Yes |  |
| Fraunhofer | Yes |  |
| Huawei | Yes, but | Our understanding is this is in SA2 scope, and it is unclear to us how it works to let gNB split PDB in L3 relay, as the remote UE is invisible to gNB. |
| vivo | Yes, with comment | If QoS parameter split by CN is adopted, existing mechanism can be reused with minor specification efforts. However, the static split cannot take actual radio link quality into account, thus it may not be an optimum solution to guarantee QoS. If CN just provides end-to-end QoS profile, then RAN can further study how to split and support QoS considering both PC5 and Uu link. |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Nokia | No | We agree with Ericsson |
| Apple | Yes |  |

In addition, [8] proposed to discuss whether remote UE can provide information on which QoS flows need to be relayed to relay. Because this proposal has AS impact, rapporteur would like to ask:

**Q7: For L3 UE-to-NW relay QoS support, do you think whether remote UE needs to provide information on which QoS flows need to be relayed to relay?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments |
| MediaTek | No  | We think that populating the information of relaying QoS flows between Remote UE and Relay UE would be subject to the function of PC5-S if supported, then this may be discussed by SA2.  |
| Futurewei | Yes? | We’re not sure about the question, but we assume the remote UE and the relay UE can establish understanding of the PC5 QoS flow used for relay purpose in L3 UE-to-Network relay. |
| Xiaomi | Not in AS | We don’t understand how AS could decide which QoS flow need to be relayed in L3 relay. The procedure could be discussed in SA2 if necessary. |
| OPPO |  | Our understanding of this question is to move issues in SA2 to RAN2, which is apparently out of competence of RAN2 |
| Ericsson | No | It is CN that performs mapping for L3 relay. There is no need for the remote UE to provide information to the relay UE. |
| Qualcomm | No | Same understanding as Ericsson. |
| CATT |  | It should be discussed by SA2. |
| Fraunhofer | No | Agree with QC, Ericsson |
| Huawei |  | We are not quite sure about the question. May need further clarification on whether the information refers to QoS parameter mapping or which QoS to relay. |
| vivo | See comments | We think which QoS flows need to be relayed is configured to remote and relay UEs by CN and this information may be exchanged during relay discovery procedures. The details are up to SA2 discussion and decision. |
| ZTE | Yes with but | It depends on SA2. |
| Lenovo | No | Not sure that we understand the point of the question. At least we agree with others that this is SA2 scope.  |
| Nokia | No |  |
| Apple | No | We think even if it is to be provided, no AS layer solution is needed.  |

#### Security of relayed connection

For L3 UE-to-NW relay, hop-by-hop security is supported in the PC5 link and Uu link. Furthermore, SA2 also proposed a solution to provide end-to-end security for the remote UE traffic via N3IWF in solution#23 [1]. Specially, Remote UE follows the procedures defined in TS 23.502 [30] clause 4.12 to register to 5GC via N3IWF and establish corresponding PDU sessions. The data traffic over the PDU sessions is protected by IPSec between the remote UE and N3IWF [1]. The protocol stack of this solution can be described as Figure.5.

Figure. 5 Protocol stacks for L3 UE-to-network relay in Solution#23 [1]

Multiple companies discussed this topic [4][5][8][13][17][28], and their views can be summarized as below:

* View 1: Leave security design/evolution of L3 UE-to-NW relay to SA2/SA3 ([4][5][8])
* View 2: RAN2 send LS to SA3 to check the security related aspects for NR sidelink relay ([17][28]), e.g. whether L3 relay can guarantee the E2E security
* View3: For the E2E security solution via N3IWF, RAN2 to study [13]:
	+ Whether remote UE and relay UE need to and how to differentiate those different traffic and discuss how remote UE and relay UE differentiate those different traffic
	+ Whether differentiate security traffic and non-security into different PC5-DRB and Uu DRB.

In Rapporteur’s understanding, SA2 had sent LS to SA3 on security requirement of UE-to-NW relay in [31]. And SA2 is studying and evaluating the E2E security via N3IWF. Thus, Rapporteur think RAN2 can wait SA2/SA3 inputs on E2E security evaluation. For the view 3, rapporteur also think it can be left to SA2/SA3 because whether there is a differentiation is provided for NAS vs UP traffic and how it is provided is CN topic and is kind of specified in SA2 that multiple PDU Sessions can be configured on relay UE by CN in solution#23 [1].

**Q8: For security of L3 UE-to-NW relay, do you agree that RAN2 leaves it to SA2/SA3 to conclude:**

* **Evaluation on whether it can guarantee the E2E security**
* **For the E2E security solution via N3IWF, whether traffic differentiation is provided for NAS vs UP and security vs non-security traffic**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | No | The study of this aspect is in the scope of RAN SID. And according to the instruction of this email discussion, “high level description of required UP/CP functionalities” should be discussed and documented.According to the SID, the enhancement in RAN on security should be studied after SA3 provides conclusion. Hence, what we should document is the status with current RAN security mechanism for L3 UE-to-Network relay. And an LS should be sent to SA3 to inform them our findings. |
| Xiaomi | Yes |  |
| OPPO |  | For security, a LS has been sent by SA2, which however only includes high level questions, we are fine to send a LS including concrete questions on L23 in order to ensure we can get the SA3 reply before the end of this study. |
| Ericsson  | Yes |  |
| Qualcomm | Yes | For LS to SA3, however, we are not sure what RAN specific security questions are identified. And we fail to see what RAN2 can do before SA3 provides conclusion to SA2.  |
| CATT |  | Agree with OPPO, we suggest RAN2 send LS to SA3. |
| Fraunhofer | Yes |  |
| Huawei |  | Agree with OPPO, we can send LS to SA3. |
| vivo | See comments | We suggest RAN2 to send a LS to SA3 for feasibility and performance of E2E security in L3 relay architecture via N3IWF.  |
| ZTE | Yes | For bullet1, we agree to leave it to SA2/SA3 to conclude. For bullete2, we think RAN2 needs to make the decision as it has large impacts on RAN2.Normally, NAS signaling will be transmitted over SRB, if RAN2 do not differentiate the NAS and UP, the QoS of NAS signaling can not be guaranteed. Similarly, N3IWF will increase the latency of security traffic as UP traffic will be disposed by remote UE’s core network. In consequence, security and non-security also need to be differentiated in AS layer.And, according to 23.502, AS layer can recognize NAS signaling/UP traffic and security/non-security traffic based on the IP information of packet, we can send a LS to SA2 for further confirmation. |
| Lenovo | Yes |  |
| Nokia | Yes | RAN2 should only send LS to SA3 if there are RAN specific questions. The general issues are covered by LS of SA2. |
| Apple |  | While it is true for SA3 to decide, we are also fine to send LS to SA3 from RAN2. |

#### Service continuity

In SA2 TR [1], the service continuity for L3 UE-to-NW relay can be guaranteed in the upper layer. According to current information, the below options may be chosen to solve L3 service continuity question:

* Support application layer service continuity using existing mechanism, e.g. TS 23.280 for MC services, TS23.237 for IMS services, etc.
* N3IWF based solution (solution#23) [1] supports SSC mode 1 and SSC mode 3 using existing mechanism.
* L3 relay baseline solution (solution#6) [1] support SSC mode 3 using existing mechanism and FFS on SSC mode 1.

For all above solutions, most companies don’t think they have RAN2 impacts [5][8][10][13][16][18], i.e. it can be left to SA2 for service continuity design / evaluation of L3 UE-to-NW relay. To make progress, rapporteur would like to confirm whether companies have same understanding.

**Q9: Do you agree RAN2 to leave service continuity design / evaluation of L3 UE-to-NW relay to SA2?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | No | The above descriptions of SA2 status on service continuity seems to be the rapporteur’s interpretation, which don’t reflect what’s in [1].And it is also confusing to cite TS 23.280 for MC services, TS23.237 for IMS services, and SSC modes as evidences that service continuity is being taken care in SA2 for L3 UE-to-Network relay. Please note that all these works exist in Rel-16 or earlier, and they don’t excuse RAN from developing handover mechanisms to support service continuity. In fact, these works are more related to service continuity during the change of PDU session anchor, which are orthogonal to the service continuity RAN is supposed to support during the change of RAN nodes.The study of this aspect is in the scope of RAN SID. And according to the instruction of this email discussion, “high level description of required UP/CP functionalities” should be discussed and documented.If nothing can/should be done in RAN for L3 UE-to-NW relay, we should document the findings, including the consequence on the service continuity during the change of RAN nodes. |
| Xiaomi | No | * Path switch also has impact on service continuity. If the path switch is triggered too late, there may be RLF, which would result in interruption. This part can be common design for L2 and L3 relay and the evaluation should be done in RAN2.
 |
| OPPO | Yes | The related procedure is apparently out of RAN2.And if it is the common view from companies, we can simply capture in the TR that for L3, the service continuity related aspects are addressed in SA2 TR. |
| Ericsson | Yes |  |
| Qualcomm | Yes |  |
| CATT | Yes |  |
| Fraunhofer | Yes, with comment | We agree that the design is out of scope of RAN2. However, we share the same view as Futurewei and Xiaomi that implications to the path switching procedure should be studied. |
| Huawei | No | We think RAN scope includes AS service continuity, and if all work on service continuity is to be left to SA2, it may mean there is no AS service continuity for L3 relay. We would like to check whether this is a RAN2 common understanding? |
| vivo | Yes |  |
| ZTE | Yes | Considering that gNB does not aware of remote UE, it is difficult to support service continuity from AS layer perspective. In consequence, service continuity need to be guaranteed by upper layer. |
| Lenovo | Yes | More in the scope of SA2. Service continuity is transparent to AS in our understanding. |
| Nokia | Yes, but (see comment) | RAN2 should investigate if the performance of service continuity can be enhanced with RAN support. |
| Apple | Yes |  |

Meanwhile, there are some proposals on gNB controlled path switch (e.g. PC5<->Uu and PC5<->PC5) [25][26] (which are not clear whether to apply to L3 UE-to-NW relay) or gNB-assisted path switch [6][16]. However, Rapporteur’s understanding is that NG-RAN is not aware of the remote UE in L3 UE-to-NW relay, and thereby gNB controlled path switch seems to be impossible, i.e. path switch in L3 UE-to-NW relay relies on relay (re)selection. For gNB-assisted path switch, Rapporteur think it should be discussed after RAN2 concluded design of relay (re)selection. To make progress:

**Q10: For L3 UE-to-NW relay, do you agree:**

* **Path switch (e.g. PC5<->Uu and PC5<->PC5) relies on relay (re)selection**
* **gNB-assisted path switch can be discussed after RAN2 concluded design of relay (re)selection**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes with but | We doubt if the relay (re)selection based path switch can really achieve the service continuity as required by SA1. |
| Futurewei | Yes | For L3 UE-to-Network relay, path switch relies on relay (re)selection. |
| Xiaomi | No | Although the path switch shall be triggered after at least one relay is selected, but we think the functionality of relay (re)selection and path switch are independent. Relay selection is controlled by upper layer. But path switch should be controlled by AS, since the sidelink and Uu status are not visible in upper layer. They can be discussed separately. |
| OPPO | There is no need to discuss it | Since for L3 relay, if any path switching e.g. PC5<->Uu and PC5<->PC5), it is invisible by RAN/AS-layer, so out of RAN2 scope. |
| Ericsson | No | Agree with OPPO. |
| Qualcomm |  | @OPPO, Ericsson: the intention is just to clarify that gNB controlled path switch is not applied to L3 UE-to-NW relay @Xiaomi: we think your proposal on path switch can be discussed in relay (re)selection because it as coupling with relay reselection. As you mentioned. |
| CATT | Yes with comment | UE has discovered a relay UE is one mandatory condition for path switch, but whether to perform the path switching should be decided by upper layer. |
| Fraunhofer | Yes, with comment | We request that gNB-assisted path switch be a part of the design for relay (re)selection |
| Huawei | FFS | We would like to ask for further clarification on the relation between path switch and service continuity. |
| vivo | Yes | At least we can take the Rel-13 UE-to-Network relay (re)selection mechanism as a starting point. |
| ZTE | Yes | Legacy LTE UE-NW relay can be taken as a baseline. |
| Lenovo |  | We agree that path switch in L3 UE-to-NW relay relies on relay (re)selection. Don’t see any RAN2 implications |
| Nokia | NO to 1st bulletYES to 2nd bullet | Relay selection and reselection and path switch should be discussed separately. |
| Apple |  | gNB-assisted relay selection and path switch are not to be supported for L3 relay deisgn |

## Control plane protocol stack of L3 UE-to-NW relay

Based on Figure 3 of the relay connection setup procedures agreed for L3 UE-to-network relay in SA2, multiple companies discussed control plane protocol stack of L3 UE-to-NW relay [3][13][16][18][22]:

* Alt-1: Remote UE has no NAS connection with AMF and PC5-S is needed for the link between remote and relay, as illustrated in Figure 6 [3][13][16][18].
	+ Note that “PC5-S” and “PC5-RRC” are put together because they were agreed to be sent in parallel in Rel-16 NR V2X
* Alt-2: Remote UE has NAS connection with AMF, as illustrated in Figure 7 ([22])
	+ Note that it may have CN impacts that requires SA2 validation (remote UE has NAS connection with AMF) if it is agreed

Figure. 6 Control plane protocol stacks of L3 UE-to-NW relay (Alt-1)

Figure. 7 Control plane protocol stacks of L3 UE-to-NW relay (Alt-2) from [22]

**Q11: Which alternatives do you prefer for control plane protocol stack of L3 UE-to-NW Relay?**

* **Alt-1: Figure 6**
	+ **Remote UE has no NAS connection with AMF**
	+ **“PC5-S” and “PC5-RRC” are put together because they were agreed to be sent in parallel**
* **Alt-2: Figure 7**
	+ **Remote UE has NAS connection with AMF**

|  |  |  |
| --- | --- | --- |
| Company | Preference (Alt-1/Alt-2) | Comments |
| MediaTek |  | We do not see the need to discuss the control protocol stack for L3 UE-to-NW relay, as Remote UE can use the legacy approach when considering NAS connection. |
| Futurewei | Alt-1 | Remote UE doesn’t have RRC connection with gNB, and can’t have NAS connection with AMF. |
| Xiaomi | Alt 1 | Alt 1 is aligned with existing framework. But we wonder whether it’s out of RAN2 scope. |
| OPPO |  | It is apparently in SA2 scope. |
| Ericsson  | Alt-1 | Alt-1 is aligned with SA2. |
| Qualcomm | Alt-1 | We share same understanding as Ericsson that it is aligned with SA2. If people have concern, we can send LS to SA2 for confirmation.We fail to understand MediaTek’s comment that Remote UE can use the legacy approach when considering NAS connection. The remote UE can be Out-of-coverage. We are not sure what is legacy approach for OOC remote UE. |
| CATT |  | Regarding to the NAS connection, it should be decided in SA2, not in RAN2. |
| Fraunhofer | Alt-2 | In principal, for UE-to-Network relaying, we believe there are several advantages to the remote UE having a NAS connection with the AMF. Both alternatives should be included in the LS to SA2 for their arbitration.  |
| Huawei |  | We agree this is in SA2’s scope, and suggest to send LS to SA2. |
| vivo | See comments | The solution for NAS connection is up to SA2. Both Alt-1 and Alt-2 are possible depending on the L3 relay architecture w/o N3IWF.  |
| ZTE | Alt-1 | For Alt-2, we think it doesn’t make sense for remote UE connect with core network in L3 relay. How gNB recognize NAS message of remote UE? If we gNB can recongnize the NAS message of remote UE, it needs remote UE to be aware by gNB, which deviate the principle of L3 relay. |
| Lenovo | Alt-1 | SA2 assumes that Remote UE has no NAS connection with AMF. Remote UE has just an IP connection with the relay UE.  |
| Nokia |  | It is not in the scope of RAN2 whether there is a NAS between Remote UE and CN. It might be better not to capture anything before SA2 concludes this issue. |
| Apple | Alt-1 | Also, we agree this is finally to be decided by SA2, no RAN2 impact foreseen. |

## Protocol stack of L3 UE-to-UE relay

There are few discussions on L3 UE-to-UE relay protocol stack (only [22] provided a figure). However, please note that following Notes of SID

*“NOTE 2: It is assumed that UE-to-network relay and UE-to-UE relay use the same relaying solution” [2].*

Rapporteur think maybe we can try to progress by assuming that the same protocol stack of UE-to-Network relay can be reused for UE-to-UE relay.

**Figure.8: User plane protocol stack for L3 UE-to-UE Relay (Alt-1)**

**Figure.9: User plane protocol stack for L3 UE-to-UE Relay (Alt-2)**

**Q12: Which alternatives do you prefer for user plane protocol stack of L3 UE-to-UE Relay?**

* **Alt-1: Figure 8 (corresponding to Alt-1 in Q1)**
* **Alt-2: Figure 9 (corresponding to Alt-2 in Q1)**

|  |  |  |
| --- | --- | --- |
| Company | Preference (Alt-1/Alt-2) | Comments |
| MediaTek | Alt-1 | Alignment to Q1 |
| Futurewei | Alt-2 | It makes clear that PC5 QoS flow between the remote UE and the end UE needs to be mapped to 1) PC5 QoS flow between the remote UE and the relay UE and 2) PC5 QoS flow between the relay UE and the end UE. These three types of QoS flows belong to 3 different PDU sessions, of unicast connections between the remote UE and the end UE, between the remote UE and the relay UE, and between the relay UE and the end UE, respectively. |
| Xiaomi | Alt-1 |  |
| OPPO |  | It is apparently in SA2 scope. |
| Ericsson | Alt-1 |  |
| Qualcomm | Alt-1 |  |
| CATT |  | SA2 scope |
| Fraunhofer | Alt-1 |  |
| Huawei |  | Same comments in Q1. |
| vivo | Alt-1 | The same protocol stack of UE-to-Network relay can be reused for UE-to-UE relay. |
| ZTE | Alt-1 | See comments in Q1 |
| Lenovo | Alt-1 |  |
| Nokia |  | This is not in the scope of RAN2. It might be better not to capture anything before SA2 concludes this issue |
| Apple | Alt-1 |  |



**Figure.10: Control plane protocol stack for L3 UE-to-UE Relay (Alt-1)**



**Figure.11: Control plane protocol stack for L3 UE-to-UE Relay (Alt-2) from [22]**

**Q13: Which alternatives do you prefer for control plane protocol stack of L3 UE-to-UE Relay?**

* **Alt-1: Figure 10 (corresponding to Alt-1 in Q11)**
* **Alt-2: Figure 11 (corresponding to Alt-2 in Q11)**

|  |  |  |
| --- | --- | --- |
| Company | Preference (Alt-1/Alt-2) | Comments |
| MediaTek |  | We do not see the need to discuss the control protocol stack for L3 UE-to-UE relay, control protocol stack should be transparent to L3 UE-to-UE relay operation. |
| Futurewei | Alt-1 | PC5-S is needed in L3 UE-to-UE relay. |
| Xiaomi | Alt 1 | Alt 1 is aligned with existing framework. But we are wondering whether it’s out of RAN2 scope. |
| OPPO |  | It is apparently in SA2 scope. |
| Ericsson | Alt-1 | PC5-S part is within SA2 scope. |
| Qualcomm | Alt-1 | If people have concern, we can send LS to SA2 for confirmation. |
| CATT |  | SA2 scope |
| Huawei |  | Share the same view with MediaTek. |
| vivo | Alt-1 | PC5-S and PC5-RRC are always together considering the signaling procedure of the Rel-16 NR V2X and can be reused. |
| ZTE | Alt-1 |  |
| Lenovo | Alt-1 | SA2 scope |
| Nokia |  | This is not in the scope of RAN2. It might be better not to capture anything before SA2 concludes this issue |
| Apple | Alt-1 | Anything involving PC5-S To be decided by SA2, although we think Alt 1 seems the apparent choice. |

For control plane procedure, SA2 is still discussing different UE-to-UE relay solutions, including L2 and L3 solution [1]. For this moment, it is difficulty for RAN2 to decide the AS impact and thereby can leave to SA2 in SA2. In addition, some use scenarios of UE-to-UE relay are not clear (e.g. service continuity). Thus, rapporteur assume that its design can be left to SA2 in SI.

Rapporteur would like to confirm whether companies have same understanding.

**Q14: For control plane procedure of L3 UE-to-UE relay, do you agree to leave it to SA2 in SI?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments (please provide comment if you think “No”) |
| MediaTek | Yes |  |
| Futurewei | No | It shouldn’t be left to SA2, as this aspect is in the RAN SID. But we do see this of lower priority, and RAN2 can focus study on UE-to-network relay. |
| Xiaomi | Yes |  |
| OPPO |  | It is apparently in SA2 scope. |
| Ericsson | No | The protocol stack is within RAN2 scope. |
| Qualcomm |  | We prefer it can be studied after L3 UE-to-NW relay design is stable because for this moment, it is difficulty for RAN2 to decide the AS impact. |
| CATT | Yes |  |
| Huawei |  | We share the same view as Qualcomm, as the RAN2 impact of U2U is not quite clear now. |
| vivo | Yes |  |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Nokia | Yes | Similar view as Qualcomm: RAN2 should start the study after SA2 selected a solution |
| Apple | Yes | SA2 to decide. No AS layer control plane procedures foreseen. |

# Summary

TBD based on companies’ inputs.

# References

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

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