SA WG2 Meeting #139E (e-meeting) S2-20xxxyy

Elbonia, June 1-12, 2020

**Source: Qualcomm Incorporated**

**Title: Additional considerations for Layer-2 UE-to-Network Relay solution**

**Document for: Discussion/Approval**

**Agenda Item: 8.8**

**Work Item / Release: 5G\_ProSe/Rel.17**

*Abstract of the contribution: This paper analyses the Solution #7: Indirect communication for Layer 2 UE-to-Network Relay UE and proposes some updates to the solution based on this analysis.*

# Background

Solution #7: Indirect communication for Layer 2 UE-to-Network Relay UE is included in TR 23.752 as a solution for the KI#3. The protocol architecture for this solution is included in the appendix as there is lack of consensus for the L2 UE-to-Network Relay control plane protocol stack. The procedures for connection establishment via L2 UE-to-Network Relay, in Figure 6.7.3-1, introduced new messages (Indirect Communication Request/Accept) for relaying connection setup. However, there is no justification on the need for these messages. Also, there are several editor's notes in the description and procedures clauses that are not addressed.

In this paper, some updates and clarifications are suggested to address these issues.

# Discussion

## 2.1 Control plane protocol stack

In the L2 UE-to-Network Relay Control plane protocol stack, clause A.2.2 of TR 23.752, the Remote is shown to have only PC5-RLC and below protocol stack. The Remote UE's NAS and NR-RRC (for Uu connection) are shown to be relayed by the L2 UE-to-Network Relay to the NG-RAN via PC5 and Uu. This means that the Remote UE and Relay UE has a unicast link and the appropriate configuration for the PC5 RLC bearers for the relaying of the messages from the Remote UE.

In clause 4.2.1 of TR 23.752, it is specified that NR V2X architecture and procedures should be considered as baseline for supporting ProSe in 5GS. In NR V2X, as defined in TS 23.287, PC5-S signaling is used to setup the PC5 unicast link and PC5-RRC signaling is used to configure the radio bearers. Thus, in order to setup a unicast link with the L2 UE-to-Network Relay, the Remote UE and L2 UE-to-Network Relay's control plane stack should also include the PC5 Control place stack as shown in Figure.1 below.

**Proposal 1: To add into the protocol stack the PC5-S and PC5-RRC that are required for the setup of one-to-one direct communication link between the Remote UE and L2 UE-to-Network Relay.**



Figure 1: Control Plane protocol stack for L2 UE-to-Network Relay

In addition, to support the operation, the PC5 RLC bearers need to be configured to carry the Remote UE traffic. For example, different PC5 RLC bearers needs to be configured to carry the signalling messages from the Remote UE, e.g. the NR-RRC, and the data traffic. Also, the L2 UE-to-Network Relay needs to be also configured with the corresponding relationship of the PC5-RLC and NR-RLC relationship for the relay operation.

Theses need to be configured by the PC5-RRC signalling and Uu signalling. However, how the Remote UE and/or the L2 UE-to-Network Relay obtains the needed information for such configuration needs to be studied, and the corresponding messages needs to be specified in collaboration with RAN WG2.

**Proposal 2: Add an editor's note on the PC5 RLC bearer and Uu RLC bearer configuration and mapping between the bearers is for FFS.**

## 2.2 User plane considerations for PC5

The user plane protocol stack for the Layer 2 UE-to-Network Relay is documented in Annex A.2.1. However, for the user plane stack, the Remote UE and the L2 UE-to-Network Relay are simplified to include on PC5-RLC/MAC/PHY layers. The PC5-SDAP layer and PC5-PDCP layer, shown in Figure 2 were absent. The SDAP layer is in charge of the QoS handling for the PC5 link, as defined in clause 5.4 of TS 23.287, and the PC5-PDCP is in charge of security.



Figure 2: User-plane Plane protocol stack for Layer 2 UE-to-Network Relay

Therefore, without the PC5-SDAP, and PC5-PDCP between the Remote UE and the L2 UE-to-Network Relay, the QoS and Security support over PC5 are lacking.

It should be documented in the solution that how the QoS over PC5 can be supported for the L2 UE-to-Network Relay requires further study. In addition, it should be also noted that without the PC5 link security protection, i.e. integrity protection, the Layer 2 UE-to-Network Relay has no way to verify the traffic is from a genuine Remote UE. This may require some additional analysis by SA3 on whether additional threats are exposed.

**Proposal 3: Add editor's note on the QoS and Security support over PC5 require additional study.**

## 2.3 Network Selection

In clause 6.7.2.3 of TR 23.752, it is specified that Remote UE performs PLMN selection and Access Network selection as part of the Network Selection. The PLMN selection is based on the PLMN selected by the Relay UE. It is not clear in the description how the Remote UE obtains this PLMN information. It is proposed to clarify this aspect.

**Proposal 4: L2 UE-to-Newtork Relay needs to provide its PLMN information to the Remote UE during discovery procedure.**

In addition, for the Access Network selection, the Remote UE needs to be configured with thresholds and criteria to decide when to use the Relay for the connection. This aspect requires further study in RAN WG2.

## 2.4 Authorization and provisioning

Clause 6.7.2.4 discusses about how the authorization and provisioning parameters are provided to the Relay UE and Remote UE for Layer 2 UE-to-Network Relay solution. However, it does not provide the details on which parameters are necessary to support the ProSe discovery and communication with the Layer 2 Relay UE. In addition, the below EN is also included which suggests there is a need to clarify the parameters necessary for out-of-coverage operation.

 “Editor's note: Whether preconfigured credentials for ProSe discovery and for initial ProSe communication on PC5 out-of-coverage are needed is FFS.”

In Layer 3 UE-to-NW relay solution, the relay discovery is based on a Relay Service Code. Relay Service Code identifies the connectivity service the ProSe UE-to-Network Relay provides, and the authorized users the ProSe UE-to-Network Relay would offer service to. Each Relay service code may also be associated with specific security parameters for discovery and initial ProSe communication setup. Given that the design should strive to have the common discovery operation, regardless of the UE-to-Network Relay architecture, the same approach shuold be used for discovering the Layer 2 UE-to-Network Relay UE and to establish the initial ProSe communication with the Relay UE.

To support out-of-coverage operation for a Remote UE, the Remote UE must be pre-configured with the necessary parameters. This aspect is already covered in the first paragraph of clause 6.7.2.4. Thus, it is proposed to clarify that the Remote UE obtains the information based on configuration in clause 6.16.3.

**Proposal 5: Clarify that the UE-to-Network Relay authorization and provisioning parameters specified in clause 6.16.3 of TR 23.752 can be reused for Layer 2 UE-to-Network Relay operation with some exceptions.**

## 2.5 Connection setup procedures

Step 4 and 5 of Figure 6.7.3-1 of Solution #7 show that Indirect communication request and Indirect communication response messages are used to setup a one-to-one direct communication link between the Remote UE and Relay UE. There are some problems with this approach:

- Does not align with the NR V2X one-to-one communication link setup procedures defined in TS 23.287. In NR V2X, PC5 unicast link setup uses the direct communication request and response messages.

- For a Remote UE, it has to support two different ways to setup the PC5 unicast link, i.e. with another UE vs. with a Relay.

Instead, it is desirable to enhance the existing NR V2X Direct communication request messages , e.g. to include an additional IE “Relay Service Code”, similar to what is defined in TS24.334 for LTE ProSe, which is used by Remote UE to indicate which type of Relay service is it expecting from Relay UE.

**Proposal 6: Reuse NR V2X Direct communication request and Direct communication response messages to setup the PC5 unicast link between Remote UE and Layer 2 UE-to-Network Relay UE.**

## 2.6 Terminology clarification

Also, in the QoS clause 6.7.2.6, we noticed some confusion with the use of Uu bearers and PC5 bearers. We clarify the terminology as below:

* Uu "radio bearers" – refer to the NR SRBs/DRBs configured between the Remote UE and the network.
* PC5 RLC bearers – refer to the PC5 RLC/MAC entities configured between the Remote UE and Relay UE, to support the Remote UE Uu radio bearer traffic relaying via the Layer 2 UE-to-Network Relay UE
* Uu RLC bearers - refer to the Uu RLC/MAC entities configured between the Relay UE and Network, to support the Remote UE Uu radio bearer traffic relaying over the Uu path of the Relay UE

# Text Proposal

It is proposed to consider the changes below for solution#7 for Key Issue #3 in TR 23.752.

**>>>>Start Changes<<<<**

### 6.7.1 Introduction

The solution addresses the following aspect highlighted in key issue #3 (Support of UE-to-Network Relay):

- How to transfer data between the Remote UE and the network over the UE-to-Network Relay UE.

The solution proposes a protocol architecture to support a Layer 2 UE-to-Network Relay UE (see Annex A).

This solution works only for NR/5GC network relays. It does not apply when the UE-to-Network Relay UE is out of coverage of NR/5GC.

**>>>>Next change<<<<**

#### 6.7.2.3 Network Selection

Network selection comprises PLMN selection and access network selection. Access network selection for a Remote UE comprises UE-to-Network relay discovery and selection. The Remote UE performs PLMN selection in accordance with the PLMN selected by the UE-to-Network Relay. The Relay UE provides its PLMN information to the Remote UE during discovery.

The Remote UE and UE-to-Network Relay UE are served by the same NG-RAN.

Editor's note: The Remote UE Access Network selection criteria for relay selection and relay (re)selection criteria are FFS in RAN WG2

#### 6.7.2.4 Authorization and provisioning

In order to enable a (Remote) UE out of coverage to gain connectivity to the network, it is important to allow such UE by means of (pre)configuration to discover potential UE-to-Network Relay UEs through which it could gain access to the 5GS. To do so:

Parameters for UE-to-Network Relay UE discovery and for communication over NR PC5 may be made available to the Remote UE as follows:

- Pre-configured in the ME and/or configured in the UICC;

- Provided or updated by the PCF to the UE in the serving PLMN.

It is also important that a UE be authorized to operate as a UE-to-Network Relay UE. A UE may only operate as a UE-to-Network Relay UE when served by the network.

Parameters for a UE to operate as a UE-to-Network Relay UE, for discovery of Remote UEs over NR PC5 and for communication over NR PC5 may be made available to the UE as follows:

- Pre-configured in the ME and/or configured in the UICC;

- Provided or updated by the PCF to the UE in the serving PLMN.

It should be possible for the HPLMN PCF to provide authorization for a UE to operate as a Remote UE or as a UE-to-Network Relay UE on a per PLMN basis. It should also be possible for the Serving PLMN to provide/revoke such authorization in which case it shall override any corresponding information provided by the HPLMN.

The parameters necessary for Remote UE and Relay UE to support L2 UE-to-NW Relay discovery and communication are as described in solution#16, with the following exceptions:

* L2 UE-to-Network Relay does not need a separate PDU session setup for relaying traffic. Thus, the associated PDU session parameters (S-NSSAI, DNN, SSC mode, etc.) to be used for relayed traffic for each UE-to-Network Relay Service Code or Service ID are not relevant to L2 UE-to-Network Relay operation.

**>>>>Next change<<<<**

#### 6.7.2.6 QoS

As shown in Annex A, the NAS endpoints between a Remote UE and the network are as currently specified such that the operation via a UE-to-Network Relay UE should be transparent to the network NAS, with the exception of authorization/provisioning identified in clause 6.7.2.4.

This means that the 5GS flow-based QoS concept in particular should be reused between the Remote UE and the network, with necessary adaptation over the radio interface i.e. PC5 (for the Remote UE and UE-to-Network Relay UE) and Uu (for the UE-to-Network Relay UE and network). In other words QoS flows established between the network and the Remote UE will be mapped to Uu "radio bearers" seen by the Remote UE and the network. The Uu radio bearers will be mapped to the PC5 RLC bearers and Uu RLC bearers seen by the Relay UE and the network , whereby the UE-to-Network Relay UE and the network performs the necessary adaptation between Uu and PC5.

Editor's note: It is FFS how the QoS is provided over the PC5 link between the Remote UE and the Layer 2 UE-to-Network Relay.

**>>>>Next change<<<<**

6.7.2.8 Security

Security (confidentiality and integrity protection) is enforced at the PDCP layer between the endpoints at the Remote UE and the gNB. 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.

Editor's note: How and where user plane integrity protection is enforced e.g. NG-RAN node or UE-to-Network Relay UE is FFS.

Editor's note: It is FFS if the lack of security protection for the PC5 link between Remote UE and Layer 2 UE-to-Network Relay can satisfy the service requirements.

NOTE: Further analysis of security requirements will be done in SA WG3.

**>>>>Next change<<<<**

### 6.7.3 Procedures



Figure 6.7.3-1: Connection Establishment for Indirect Communication via UE-to-Network Relay UE

0. If in coverage, the Remote UE and UE-to-Network Relay UE may independently perform the initial registration to the network according to registration procedures in TS 23.502 [8]. During the registration procedure, L2 UE-to-NW relay service Authorization and provisioning is performed for the ProSe UE-to-NW relay and Remote UE and the parameters for L2 UE-to-NW discovery and communication are provided as specified in clause 6.7.2.4.

 The allocated 5G GUTI of the Remote UE is maintained when later NAS signaling between Remote UE and Network is exchanged via the UE-to-Network Relay UE.

 NOTE: The current procedures shown here assume a single hop relay.

Editor's note: Details of security credentials to set up a security context for subsequent PC5 communication between the Remote UE and the UE-to-Network Relay UE are FFS.

To support the Remote UE perform L2 UE-to-NW Relay discovery and PC5 connection setup when out-of-coverage, the service authorization and provisioning parameters can be pre-configured in the Remote UE. Remote UE uses the pre-configured information to discover and connect to the Relay UE. After Remote UE performs initial Registration via the Relay UE, the network can update the authorization information of the Remote UE.

1. Using the provisioned parameters, the Remote UE performs discovery of L2 Relay UE using any solution for KI#1 and KI#3. As part of the discovery procedures, Remote UE learns about the Relay UE network information and the connectivity service the Relay UE provides.

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Editor's note: UE-to-Network Relay selection criteria and the procedures are FFS in RAN WG2.

2. Remote UE initiates a one-to-one communication connection with the selected UE-to-Network Relay UE over PC5 using the procedure dsescribed in TS 23.287 [5].

3. If the UE-to-Network Relay UE is in CM\_IDLE state, triggered by the PC5 one-to-one communication connection setup with the Remote UE, the UE-to-Network Relay UE sends a Service Request message over PC5 to its serving AMF.

 The Relay's AMF may perform authentication of the UE-to-Network Relay UE based on NAS message validation and if needed the AMF will check the subscription data,as per the procedures described in clause 4.2.3.2 of TS23.502.

 If the UE-to-Network Relay UE is already in CM\_CONNECTED state and is authorized to perform Relay service then step 3 is omitted.

Editor's note: Whether AMF needs to further interact with PCF is FFS.

Editor's note: Potential interaction between the Relay UE's AMF and Remote UE's AMF is FFS.

4. Remote UE sends AS messages to the NG-RAN via the UE-to-NW Relay UE, to establish an AS Connection with the same NG-RAN serving the Relay UE.

5. Remote sends a NAS message to the serving AMF. The NAS message is encapsulated in an RRC message that is sent over PC5 to the UE-to-Network Relay UE, and the UE-to-Network Relay UE forwards the message to the NG-RAN. The NG-RAN derives Remote UE's serving AMF and forwards the NAS message to this AMF.

Editor's note: How the NG-RAN derives the Remote UE's AMF is FFS.

NOTE: It is assumed that the Remote UE's PLMN is accessible by the UE-to-Network Relay's PLMN and that UE-to-Network Relay UE AMF supports all S-NSSAIs the Remote UE may want to connect to.

Editor's note: Interaction between the Relay UE's AMF and Remote UE's AMF is FFS.

 If Remote UE has not performed the initial registration to the network in step 0, the NAS message is initial registration message. Otherwise, the NAS message is either a service request message or Registration message based on the registered area of the Remote UE.

Editor's note: How the UE-to-Network Relay UE forwards the message to the NG-RAN depends on RAN specified L2 relay method.

 If the Remote UE performs initial registration via the UE-to-Network relay, the Remote UE's serving AMF may perform authentication of the Remote UE based on NAS message validation and if needed the Remote UE's AMF checks the subscription data.

 For service request case, User Plane connection for PDU Sessions can also be activated. The other steps follow the clause 4.2.3.2 in TS 23.502 [8].

6. Remote UE may trigger the PDU Session Establishment procedure as defined in clause 4.3.2.2 of TS 23.502 [8]. Remote UE allowed PDU session related attributes while operating via the UE-to-NW Relay UE are provided during the registration procedure or through pre-configuration as described in step 0.

7. The data is transmitted between Remote UE and UPF via UE-to-Network Relay UE and NG-RAN. The UE-to-Network Relay UE forwards all the data messages between the Remote UE and NG-RAN using RAN specified L2 relay method.

Editor's note: How to handle the PDU Session related attributes (e.g. S-NSSAI) regarding the relay scenario is FFS.

Editor's note: How the NG-RAN releases the Remote UE's resources when the Relay UE disconnects is FFS.

### 6.7.4 Impacts on services, entities and interfaces

The solution has impacts in the following entities:

**UE:**

- Needs to support enhanced Uu AS layer procedures for Remote UE and ProSe 5G UE-to-Network Relay.

**>>>>Next change<<<<**

Annex A:
Layer 2 Architecture Reference Model

# A.1 Introduction

The following clauses describe the control plane and user plane protocol stacks for supporting Layer 2 evolved UE-to-Network Relay UE, in case of 3GPP access.

# A.2 Control and User Plane Protocols

## A.2.1 User Plane Protocol Stack

Figure A.2.1-1, illustrates the protocol stack for the user plane transport, related to a PDU Session, including a Layer 2 UE-to-Network Relay UE. The PDU layer corresponds to the PDU carried between the Remote UE and the Data Network (DN) over the PDU session. The PDU layer corresponds to the PDU carried between the Remote UE and the Data Network (DN) over the PDU session. The SDAP and PDCP protocols are as specified in TS 38.300 [11]. It is important to note that the two endpoints of the PDCP link are the Remote UE and the gNB. The relay function is performed below PDCP. This means that data security is ensured between the Remote UE and the gNB without exposing raw data at the UE-to-Network Relay UE.



Figure A.2.1-1: User Plane Stack for L2 UE-to-Network Relay UE

The adaptation rely layer within the UE-to-Network Relay UE can differentiate between signalling radio bearers (SRBs) and data radio bearers (DRBs) for a particular Remote UE. The adaption relay layer is also responsible for mapping PC5 traffic to one or more DRBs of the Uu. The definition of the adaptation relay layer is under the responsibility of RAN WG2.

Editor's note: The details of the services provided by the adaption layer is left to RAN WG2.

## A.2.2 Control Plane Protocol Stack

Figure A.2.2-1, illustrates the protocol stack of the NAS connection for the Remote UE to the NAS-MM and NAS-SM components. The NAS messages are transparently transferred between the Remote UE and 5G-AN over the Layer 2 UE-to-Network Relay UE using:

- PDCP end-to-end connection where the role of the UE-to-Network Relay UE is to relay the PDUs over the signalling radio bear without any modifications.

- N2 connection between the 5G-AN and AMF over N2.

- N3 connection AMF and SMF over N11.

The role of the UE-to-Network Relay UE is to relay the PDUs from the signalling radio bearer without any modifications.



Figure A.2.2-1: Control Plane for L2 UE-to-Network Relay UE

Editor's note: The Remote UE behaviour at the RRC layer is FFS in RAN WG2.

Editor's note: It is FFS how the PC5 RLC bearer and NR Uu RLC bearer configuration and mapping between the bearers can be supported.

**>>>>End Changes<<<<**