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| Technical Report |

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| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  Study on NR sidelink relay;  (Release 17) |

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document is related to Study on NR Sidelink Relay with a scope as defined in [2].

The document describes NR enhancements to support sidelink relay, which were analyzed as part of the study such as sidelink-based UE-to-NW and UE-to-UE Relay, and discovery model/procedure for sidelink relaying.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP RP-193253 "New SID: Study on NR sidelink relay".

[3] 3GPP TS 23.303 "Proximity-based services (ProSe);Stage 2 ".

[4] 3GPP TS 38.300 "NR; Overall description; Stage-2".

[5] 3GPP TS 38.321 "NR;Medium Access Control (MAC) protocol specification".

[6] 3GPP TR 23.752 "Study on system enhancement for Proximity based Services (ProSe) in the 5G System (5GS)".

[7] 3GPP TR 36.746 " Study on further enhancements to LTE Device to Device (D2D), UE to network relays for Internet of Things (IoT) and wearables".

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[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

Abbreviation format (EW)

<ABBREVIATION> <Expansion>

# 4 Sidelink-based UE-to-network Relay

## 4.1 Scenarios, Assumptions and Requirments

The UE-to-NW Relay enables coverage extension and power savings for the remote UE. The coverage scenarios considered in this study are the following:

- UE-to-NW Relay UE in coverage and Remote UE out of coverage

- UE-to-NW Relay UE and Remote UE both in coverage

- For UE-to-NW Relay, the scenario where a remote UE in coverage of a first cell connects to a relay UE which is connected/in coverage of a different cell (or vice versa) is supported.

*Editor’s note: RAN2 will strive for a common solution between same cell and different cell cases for this scenario. If a common solution is not possible and impacts are found to supporting different cell case, RAN2 works on the same cell case with higher priority.*

The considered scenarios are reflected in Figure 4.1-1.



Scenario 1: Remote UE is OOC and UE-to-NW relay is IC

Scenario 2: Remote UE is IC and UE-to-NW relay is IC

Scenario 3: Remote UE is in different gNB coverage than UE-to-NW relay

Figure 4.1-1 Scenarios for UE-to-NW Relay

NR Uu is assumed on the Uu link of the UE-to-NW Relay UE. NR sidelink is assumed on PC5 between the remote UE(s) and the UE-to-NW Relay UE.

Cross-RAT configuration/control of remote UE or UE-to-NW Relay UE is not considered, i.e., eNB is not allowed to control/configure an NR remote UE and UE-to-NW relay UE. For UE-to-NW Relay, the study focuses on unicast data traffic between the remote UE and the NW.

Configuring/scheduling of a UE (either remote or UE-to-NW relay UE) by the SN to perform NR sidelink communication is out of scope of this study.

For UE-to-NW Relay, relaying of unicast data between the remote UE and the network can occur after a PC5-RRC connection is established between the relay UE and the remote UE.

For L3 UE-to-NW Relay:

- The Uu RRC state of the relay UE and remote UE can change when connected via PC5. Both relay UE and remote UE can perform relay discovery in any RRC state. A remote UE can perform relay discovery while out of coverage.

- A relay UE must be in RRC\_CONNECTED to perform relaying of unicast data.

For L2 UE-to-NW Relay:

- The Uu RRC state of the relay UE and remote UE can change when connected via PC5. Both relay UE and remote UEs can perform relay discovery in any RRC state. A remote UE can perform relay discovery while out of coverage.

- Both relay UE and remote UE must be in RRC CONNECTED to perform active relaying of unicast data.

- The relay UE can be either in RRC\_IDLE or RRC\_CONNECTED as long as all the PC5-connected remote UE(s) are in RRC\_IDLE.

## 4.2 Discovery

Model A and model B discovery model as defined in clause 5.3.1.2 of TS 23.303 [3] are taken as a working assumption for both UE-to-NW Relay and UE-to-UE Relay. The protocol stack of discovery message is similar or identical to PC5-S signalling as illustrated in Figure 16.9.2.1-1 of 38.300 [4].

*Editor note: It is FFS whether a new SL SRB is introduced for discovery message.*

*Editor note: It is FFS what solution is needed to differentiate discovery message in AS layer from existing SL signalling or traffic.*

For UE-to-NW Relay, the relay UE needs to respect a minimum and a maximum Uu signal strength threshold(s) provided by gNB before it can transmit discovery message when it is in RRC\_IDLE or RRC\_INACTIVE state. NR sidelink communication configuration provided by gNB is necessary for a Relay UE to transmit discovery message in all RRC states.

For UE-to-NW Relay,

- The remote UE in RRC\_IDLE state is allowed to transmit discovery message if measured signal strength of serving cell is lower than a configured threshold.

- Whether remote UE in RRC\_CONNECTED is allowed to transmit discovery is based on configuration provided by serving gNB.

- Remote UE out of coverage is always allowed to transmit discovery message based on pre-configuration while not connected with network through a relay UE yet.

*Editor note: For relay UE or remote UE in RRC\_CONNECTED state, it is FFS for the case serving gNB is not SL-Capable.*

*Editor note: For remote UE in RRC\_IDLE or RRC\_INACTIVE state, the details of the idle measurements and possible additional network configuration is FFS.*

*Editor note: For remote UE out of coverage, it is FFS whether transmission of discovery message is based on configuration from network if the remote UE is already connected with network through a relay UE.*

*Editor note: For remote UE in RRC\_CONNECTED, the detail of configuration provided by serving gNB is FFS.*

## 4.3 Relay (re-)selection criterion and procedure

## 4.4 Relay/Remote UE authorization

It is concluded that no impact on both control and user plane protocol stack of Uu interface is foreseen due to authorization of both Relay UE and remote UE. The impact to NG interface, if any, will be done in normative work item phase for UE-to-NW relay only.

## 4.5 Layer-2 Relay

### 4.5.1 Architecture and Protocol Stack

#### 4.5.1.1 Protocol Stack

The protocol stacks for the user plane and control plane of NR L2 UE-to-NW Relay architecture are described in Figure 4.5.1.1-1 and Figure 4.5.1.1-2.

For L2 UE-to-NW Relay, the adaptation layer is placed over RLC sublayer for both CP and UP at the Uu interface between Relay UE and gNB. The 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-NW Relay UE and the link between UE-to-NW Relay UE and the gNB).

*Editor note: It is FFS if the adaptation layer is also supported at the PC5 interface between Remote UE and Relay UE.*



Figure 4.5.1.1-1: User plane stack for L2 UE-to-NW Relay



Figure 4.5.1.1-2: Control plane protocol stack for L2 UE-to-NW Relay

#### 4.5.1.2 Adaptation layer functionality

As a working assumption, some information is put within the header of the adaptation layer to enable bearer mapping for L2 UE-to-NW relay and the details can be discussed at WI phase.

*Editor note: It is FFS if N-to-1 bearer mapping from PC5 RLC channels to Uu interface RLC channel is supported for this case.*

### 4.5.2 QoS

### 4.5.3 Security

As described in section 6.7.2.8 of TR 23.752, in case of L2 UE-to-NW Relay, the 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-NW Relay UE and the other between the UE-to-NW Relay UE to the gNB without exposing any of the Remote UE’s plaintext data to the UE-to-NW Relay.

*Editor Note: RAN2 needs to consider SA3 input for security aspects.*

### 4.5.4 Service Continuity

### 4.5.5 Control Plane Procedure

*Editor notes: Service continuity related CP procedure is captured in 4.5.4.*

#### 4.5.5.1 Connection Establishment

Remote UE needs to establish its own PDU sessions/DRBs with the network before user plane data transmission.

PC5-RRC aspects of 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 UE-to-NW relaying before Remote UE establishes a Uu RRC connection with the network via Relay UE.

For both in-coverage and out-of-coverage cases, when the Remote UE initiates the first RRC message for its connection establishment with gNB, the PC5 L2 configuration for the transmission between the Remote UE and the UE-to-NW Relay UE can be based on the RLC/MAC configuration defined in specifications.

*Editor Note: It is FFS if this PC5 L2 configuration is a default configuration that can be overridden.*

The establishment of Uu SRB1/SRB2 and DRB of the Remote UE is subject to legacy Uu configuration procedures for L2 UE-to-NW Relay.

#### 4.5.5.2 Paging

The Option 2 as studied in TR36.746 [7] for FeD2D paging is selected as the baseline paging relaying solution for L2 based UE-to-NW relaying case (i.e. Relay UE monitors the Remote UE’s Paging Occasion(s) in addition to its own Paging Occasion(s).)

#### 4.5.5.3 System Information Delivery

## 4.6 Layer-3 Relay

### 4.6.1 Architecture and Protocol Stack

SA2 captured two user plane protocol stacks for L3 UE-to-NW Relay in TR 23.752 (Figure 6.6.1-2 of solution#6 and Figure 6.23.2-3 of solution#23), which are illustrated in Figure 4.6-1 and Figure 4.6-2. No impacts are identified to support them from RAN2 perspective.



Figure 4.6-1: user plane protocol stack of L3 UE-to-NW Relay captured in solution#6 of [6]



Figure 4.6-2: user plane protocol stack of L3 UE-to-NW Relay captured in solution#23 of [6]

SA2 captured control plane protocol stacks of L3 UE-to-NW Relay in solution#6 of TR 23.752 [6]. RAN2 leaves its design to SA2.

### 4.6.2 QoS

The basic QoS support mechanism for L3 UE-to-NW Relay is illustrated in Figure 4.6-3 from TR 23.752 [6].



Figure 4.6-3: basic QoS support mechanism of L3 UE-to-NW Relay captured in [6]

SA2 captured two solutions for QoS support of L3 UE-to-NW Relay:

1) PCF sets separate Uu QoS parameters and PC5 QoS parameters in solution#25 of TR 23.752 [6].

2) End-to-End QoS support in solution#24 of TR 23.752 [6], where relay UE can obtain a mapping between PQI and 5QI from SMF/PCF.

Remote UE doesn’t need to provide information on which QoS flows need to be relayed to relay in AS layer. RAN2 don’t intend to study QoS enhancement for L3 UE-to-NW Relay.

*Editor notes: whether other QoS solution (e.g. whether gNB can perform PDB split) is introduced depends on SA2.*

*Editor notes: RAN2 can discuss AS impacts related to SA2 specified QoS solutions.*

### 4.6.3 Security

SA2 captured two solutions for security support of L3 UE-to-NW Relay:

1) Via legacy Uu security and PC5 security;

2) Via N3IWF in solution #23 of TR 23.752 [6];

*Editor notes: whether the SA2 captured solutions can satisfy the security requirement depends on SA3.*

*Editor notes: whether other security solution is introduced depends on SA2.*

### 4.6.4 Service Continuity

### 4.6.5 Control Plane Procedure

*Editor notes: Service continuity related CP procedure is captured in 4.6.4.*



Figure 4.6-4: basic connection setup procedure of L3 UE-to-NW Relay based on Figure 6.6.2-1 of [6]

The basic connection setup procedure is illustrated in Figure 4.6-4 which is based on Figure 6.6.2-1 in TS 23.752 [6]. Among them, the following procedures are identified with RAN2 impacts:

- Step 2: the discovery procedure, which is described in Section 4.2.

- Step 3: the relay (re)selection procedure, which is described in Section 4.3.

- Step 4: Rel-16 NR V2X PC5-RRC establishment procedure is reused to setup a secure unicast link between Remote UE and Relay UE before unicast traffic relaying.

*Editor notes: whether new PC5-S signaling is also introduced depends on SA2.*

# 5 Sidelink-based UE-to-UE Relay

## 5.1 Scenario, Assumption and Requirement

The UE-to-UE Relay extends the coverage of the sidelink transmissions between two sidelink UEs. The coverage scenarios considered in this study are the following:

1) All UEs (Source UE, Relay UE, Destination UE) are in coverage.

2) All UEs (Source UE, Relay UE, Destination UE) are out-of-coverage.

3) Partial coverage whereby at least one of the UEs involved in relaying (Source UE, Relay UE, Destination UE) is in-coverage, and at least one of the UEs involved in relaying is out-of-coverage.

*Editor’s note: RAN2 will strive for a common solution to the in- and out-of-coverage cases.*

For the UE-to-UE Relay, the scenario where UEs can be in coverage of the different cell is supported.

*Editors’s note: RAN2 will strive for a common solution between same cell and different cell cases for this scenario. If a common solution is not possible and impacts are found to supporting different cell case, RAN2 works on the same cell case with higher priority.*

Figure 5.1-1 shows the scenarios considered for UE-to-UE Relay. In Figure 5.1-1, coverage implies that the Source/Destination UE and/or UE-to-UE Relay UE are in coverage and can access the network on Uu.

Destination UE

Source UE

Source UE

Destination UE

Source UE

Destination UE

Destination UE

Source UE



Scenario 1: IC scenario where all Source/Destination UEs and UE-to-UE Relay are IC



Scenario 2: OOC scenario where all Source/Destination UEs and UE-to-UE Relay are OOC



Scenario 3a: Partial Coverage scenario where Source UE is IC and UE-to-UE Relay and Destination UE are OOC



Scenario 3b: Partial Coverage scenario where Source is IC and UE-to-UE Relay and Destination UE are OOC



Figure 5.1-1: Scenarios for UE-to-UE Relay

NR sidelink is assumed on PC5 between the remote UE(s) and the UE-to-NW Relay.

Cross-RAT configuration/control of Source UE, UE-to-UE Relay and Destination UE is not considered, i.e., eNB is not allowed to control/configure an NR source UE, destination UE or UE-to-UE Relay UE. For UE-to-UE Relay, this study focuses on unicast data traffic between the source UE and the destination UE.

Configuring/scheduling of a UE (source UE, destination UE or UE-to-UE Relay UE) by the SN to perform NR sidelink communication is out of scope of this study.

For UE-to-UE Relay, it is assumed that the remote UE has an active end-to-end connection via only a single relay UE at a given time.

Relaying of data between a Source UE and a Target UE can occur once a PC5 link is established between the source UE, UE-to-UE Relay, and Target UE.

No restrictions are assumed on the RRC states of any UEs involved in UE-to-UE Relaying.

## 5.2 Discovery

Model A and model B discovery model as defined in clause 5.3.1.2 of TS 23.303 [3] are taken as a working assumption for both UE-to-NW Relay and UE-to-UE Relay. The protocol stack of discovery message is similar or identical to PC5-S signalling as illustrated in Figure 16.9.2.1-1 of 38.300 [4].

*Editor note: It is FFS what solution is needed to differentiate discovery message in AS layer from existing SL signalling or traffic.*

*Editor note: It is FFS whether a new SL SRB is introduced for discovery message.*

## 5.3 Relay (re-)selection criterion and procedure

## 5.4 Relay/Remote UE authorization

## 5.5 Layer-2 Relay

### 5.5.1 Architecture and Protocol Stack

For L2 UE-to-UE Relay architecture, the protocol stacks are similar to L2 UE-to-NW Relay other than the fact that the termination points are two Remote UEs. The protocol stacks for the user plane and control plane of L2 UE-to-UE Relay architecture are described in Figure 5.5.1-1 and Figure 5.5.1-2.

An adaptation layer is supported over the second PC5 link (i.e. the PC5 link between Relay UE and receiving Remote UE) for L2 UE-to-UE Relay. For L2 UE-to-UE Relay, the adaptation layer is put over RLC sublayer for both CP and UP over the second PC5 link. The sidelink SDAP/PDCP and RRC are terminated between two Remote UEs, while RLC, MAC and PHY are terminated in each PC5 link.

*Editor note: It is FFS if the adaptation layer is also supported over the first PC5 link (i.e. the PC5 link between the transmitting Remote UE and Relay UE).*



Figure 5.5.1-1: User plane protocol stack for L2 UE-to-UE Relay



Figure 5.5.1-2: Control plane protocol stack for L2 UE-to-UE Relay

As a working assumption, some needed information is put within the header of adaptation layer between Relay UE and the receiving Remote UE to enable Bearer mapping for L2 UE-to-UE Relay and the details can be discussed at WI phase.

*Editor Note: It is FFS on the details to support the N-to-1 mapping between the ingress RLC channels from multiple transmitting Remote UEs to egress RLC channels (going to the same receiving Remote UE) at Relay UE.*

### 5.5.2 QoS

### 5.5.3 Security

As described in section 6.9.1.2 of TR 23.752, in case of L2 UE-to-UE Relay, the security is established at PDCP layer in an end to end manner between UE1 and UE2. Therefore, user data is never exposed at the relay node since the relay function does not process/apply any security on relayed IP packets.

*Editor Note: RAN2 needs to consider SA3 input.*

### 5.5.4 Control Plane Procedure

## 5.6 Layer-3 Relay

### 5.6.1 Architecture and Protocol Stack

SA2 captured protocol stacks of L3 UE-to-UE Relay in solution#10 of TR 23.752 [6]. RAN2 leaves its design to SA2.

### 5.6.2 QoS

### 5.6.3 Security

### 5.6.4 Control Plane Procedure

# 6 Comparison

## 6.1 Comparison of UE-to-Network Relay

## 6.2 Comparison of UE-to-UE Relay

# 7 Conclusion

Annex A: Change history

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2020-08 | RAN2#110 | R2-2006602 |  |  |  | Skeleton TR | 0.0.0 |