**3GPP TSG RAN WG2 Meeting #116bis R2-22XXXXX
Electronic Meeting, 17th - 25th Jan 2022**

**Agenda item: 6.2.3**

**Source: CATT**

**Title: Summary [POST116-e][710][V2X/SL] PDCP/RLC Entity Maintenance for SL-SRBs (CATT)**

**Document for: Discussion and Decision**

# Introduction

This is for the email discussion:

* [POST116-e][710][V2X/SL] PDCP/RLC Entity Maintenance for SL-SRBs (CATT)

 **Scope:** Clarify the issue and discuss solution (if the issue is confirmed).

 **Intended outcome:** Discussion summary and CR (if needed)

**Deadline:** Long email discussion. Recommend to have short intermediate phase to check if you list all options/solutions companies mind when to discuss solution.

The above email discussion is divided in three phases:

* **Phase I:** Companies are invited to check the questions and provide your option for each question if it is not included in the candidate options by 12/3, 10:00am UTC. The intention for this phase is to clarify the questions and check if all options/solutions have been listed.
* **Phase II:** Companies are invited to provide feedback on the questions of this email discussion by 12/10, 10:00am UTC.
* **Phase III:** Rapporteur submits a summary and proposals based on the feedback, and companies can comment on the summary by 12/16, 10:00pm UTC.

# Discussion

## Scenarios

According to TS 33.536, for sidelink unicast, the high-level signaling flow of connection establishment is as below:



**Figure-1 High-level signaling flow of connection establishment**

The cast type of each PC5-S message in the above Figure-1 is summarized in the following Table-1 based on the descriptions of TS 23.287 and TS 24.587.

**Table-1 Cast type of each PC5-S signalling during PC5-S connection establishment procedure**

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| --- | --- | --- |
| PC5-S signaling | Cast type  | Reference |
| DIRECT LINK ESTABLISHMENT REQUEST | Unicast or broadcast | **TS23.287**UE-1 sends the Direct Communication Request message via PC5 broadcast or unicast using the source Layer-2 ID and the destination Layer-2 ID. |
| DIRECT LINK AUTHENTICATION REQUEST | Unicast | **TS24.587**After the DIRECT LINK AUTHENTICATION REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication. |
| DIRECT LINK AUTHENTICATION RESPONSE | Unicast | **TS24.587**After the DIRECT LINK AUTHENTICATION RESPONSE message is generated, the target UE shall pass this message to the lower layers for transmission along with the target UE's layer-2 ID for unicast communication and the initiating UE's layer-2 ID for unicast communication. |
| DIRECT LINK SECURITY MODE COMMAND | Unicast | **TS24.587**After the DIRECT LINK SECURITY MODE COMMAND message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, …… |
| DIRECT LINK SECURITY MODE COMPLETE | Unicast | **TS24.587**After the DIRECT LINK SECURITY MODE COMPLETE message is generated, the target UE shall pass this message to the lower layers for transmission along with the target UE's layer-2 ID for unicast communication and the initiating UE's layer-2 ID for unicast communication, NRPIK, NRPEK if applicable, KNRP-sess ID,…… |
| DIRECT LINK ESTABLISHMENT ACCEPT  | Unicast | **TS24.587**After the DIRECT LINK ESTABLISHMENT ACCEPT message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, …... |

For the first PC5-S unicast message reception, there is the risk that the Rx UE can’t aware the Tx UE’s L2 SRC ID. In order to make it clear, we listed the detailed scenarios as below:

* Scenario 1: The first PC5-S unicast message is DCR.
* Scenario 2: The first PC5-S unicast message is DIRECT LINK AUTHENTICATION REQUEST.
	+ In this scenario, the cast type of DCR is broadcast.
* Scenario 3: The first PC5-S unicast message is DIRECT LINK SECURITY MODE COMMAND.
	+ In this scenario, the cast type of DCR is broadcast and the DIRECT LINK AUTHENTICATION REQUEST/RESPONSE procedure is omitted.

### 2.1.1 Scenario 1 (The first PC5-S unicast message is DCR)

 Scenario 1 is shown in the following figure, where the cast type of the DCR message is unicast.



**Figure-2 Scenario 1**

According to TS 24.587, the condition for UE\_1 transmitting DCR to UE\_2a by unicast is as below:

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| NOTE:      The target UE may reuse the target UE's layer-2 ID used in the transport of the DIRECT LINK ESTABLISHMENT REQUEST message provided by the lower layers in case that the target UE's layer-2 ID has been used in previous PC5 unicast link with the same peer.   |

That is to say, if UE\_1 had been setup PC5 unicast link with UE\_2a before, it may store the destination layer-2 ID of UE\_2a. If it wants to setup PC5 unicast link with UE\_2a again, it can use the stored destination layer-2 ID of UE\_2a. But in fact, UE\_2a may not store the source layer-2 ID of UE\_1 after the previous PC5 unicast link release because UE\_2a does not know whether and when the UE\_1 will re-initiate PC5 unicast link establishment procedure again. Hence, for scenario 1, it is possible that the UE\_2a does not know the L2 SRC of UE\_1 if DCR is transmitted via unicast.

**Question 1-1: For scenario 1, do companies agree that it is possible that UE\_2a does not know the source layer-2 ID of UE\_1 if DCR is transmitted via unicast?**

### 2.1.2 Scenario 2 (The first PC5-S unicast message is DIRECT LINK AUTHENTICATION REQUEST unicast)

In this scenario, as shown in the following figure, the DCR message uses broadcast and the DIRECT LINK AUTHENTICATION REQUEST message uses unicast.



**Figure-3 Scenario 2**

According to the above Figure-3, for UE\_2a, after the DIRECT LINK AUTHENTICATION REQUEST message is generated, UE\_2a shall pass this message to the lower layers for transmission along with the UE\_2a's source layer-2 ID for unicast communication and the target UE's destination layer-2 ID for unicast communication.

According to the description in TS 23.287, it clearly stated that the source layer-2 ID are always self-assigned. Hence, it is obvious that UE\_1 can’t aware the source layer-2 ID used by UE\_2a.

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| 5.6.1 Identifiers for V2X communication over PC5 reference point…….Each UE has one or more Layer-2 IDs for V2X communication over PC5 reference point, consisting of:- Source Layer-2 ID(s); and- Destination Layer-2 ID(s).Source and destination Layer-2 IDs are included in layer-2 frames sent on the layer-2 link of the PC5 reference point identifying the layer-2 source and destination of these frames. Source Layer-2 IDs are always self-assigned by the UE originating the corresponding layer-2 frames. |

**Question 1-2: For scenario 2, do companies agree that UE\_1 does not know the source layer-2 ID of UE\_2a when UE\_1 sends DCR by broadcast and UE\_2a sends DIRECT LINK AUTHENTICATION REQUEST message to UE\_1 by unicast?**

### 2.1.3 Scenario 3 (The first PC5-S unicast message is DIRECT LINK SECURITY MODE COMMAND)

In this scenario, as shown in the following figure, the DCR message uses broadcast, the DIRECT LINK AUTHENTICATION REQUEST/RESPONSE messages are absent, and the DIRECT LINK SECURITY MODE COMMAND is the first PC5-S unicast message.



**Figure-4 Scenario 3**

In this scenario, after the DIRECT LINK SECURITY MODE COMMAND message is generated, UE\_2a shall pass this message to the lower layers for transmission along with the UE\_2a’s source layer-2 ID for unicast communication and the UE\_1’s destination layer-2 ID for unicast communication.

Similar as the analysis in section 2.1.2, the source layer-2 ID of UE\_2a is self-assigned by UE\_2a, it is obvious that UE\_1 can’t aware the source layer-2 ID used by UE\_2a.

**Question 1-3: For scenario 3, do companies agree that UE\_1 does not know the source layer-2 ID of UE\_2a when UE\_1 sends DCR by broadcast and UE\_2a sends DIRECT LINK SECURITY MODE COMMAND message to UE\_1 by unicast?**

## Issue description

### 2.2.1 MAC filtering issue for the first PC5-S unicast message during PC5-S connection setup procedure

As stated in section 2.1, when receiving the first PC5-S unicast message during PC5-S connection setup procedure, it is possible that the Rx UE can’t aware the source layer-2 ID used by the Tx UE. In this case, there may be filtering issue in MAC. The detailed issue is described as below.

According to the TS 38.321, when Rx UE receives a sidelink unicast TB from Tx UE, the corresponding behaviors are as below:

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| 5.22.2.2.2 Sidelink process……1> if the data for this TB was successfully decoded before:2> if this is the first successful decoding of the data for this TB:3> if this TB is associated to unicast, the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Source Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI, and the SRC field of the decoded MAC PDU subheader is equal to the 16 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 8 LSB are equal to the Source ID in the corresponding SCI; or3> if this TB is associated to groupcast or broadcast and the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI:4> deliver the decoded MAC PDU to the disassembly and demultiplexing entity;2> consider the Sidelink process as unoccupied.… … |

From the above description, it is obvious that for sidelink unicast, before delivering the decoded MAC PDU to the disassembly and demultiplexing entity, UE should check if both of the following two conditions are met:

* The DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Source Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI;
* The SRC field of the decoded MAC PDU subheader is equal to the 16 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 8 LSB are equal to the Source ID in the corresponding SCI.

Hence, for sidelink unicast, if the Rx UE can’t aware the source layer-2 ID of the Tx UE, it can’t complete the MAC filtering. Hence, the decoded MAC PDU will not be delivered to the disassembly and demultiplexing entity.

**Question 2-1: For sidelink unicast, do companies agree that the Rx UE will not deliver the decoded MAC PDU to the disassembly and demultiplexing** **entity if it doesn’t know the source layer-2 ID used by the Tx UE?**

For companies who answer “Yes” for at least one of the Question 1-1, Question 1-2 and Question 1-3 in section 2.1 are encouraged to answer the following question further:

**Question 2-2: If companies answer “Yes” for at least one of Question 1-1, Question 1-2 and Question 1-3, do companies confirm that the Rx UE will not deliver the decoded MAC PDU to the disassembly and demultiplexing entity for the scenario(s) that the Rx UE doesn’t know the source layer-2 ID used by the Tx UE?**

### 2.2.2 PDCP/RLC receiving entity establishment issue

In RAN2#107 meeting, regarding to the PDCP/RLC entity establishment, the following agreements were reached:

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| For NR Sidelink unicast, the establishment and release of transmitting PDCP entity and receiving PDCP entity can be requested by upper layer. For NR SL unicast, RLC TX side and RX side establishment/release is triggered by upper layer request. FFS the case for RLC TX side re-establishment. |

Based on the above agreements, it is obvious that, for sidelink unicast, both the transmitting and the receiving PDCP/RLC entity establishment are triggered by upper layer. Here, the upper layer refers the RRC layer.

But according to the current TS38.331, for SL-SRB 0/1/2, there is only RRC triggers for establishing the transmitting PDCP/RLC entities, but there is no description on how to establish the receiving PDCP/RLC entities.

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| 5.8.9.1a.4            Sidelink SRB additionThe UE shall:1>  if transmission of PC5-S message for a specific destination is requested by upper layers for sidelink SRB:2>  establish PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-S message, as specified in sub-clause 9.1.1.4;1>  if a PC5-RRC connection establishment for a specific destination is indicated by upper layers:2>  establish PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-RRC message of the specific destination, as specified in sub-clause 9.1.1.4;2>  consider the PC5-RRC connection is established for the destination. |

Someone may argue that the PDCP entity and RLC entity marked with gray in TS38.331 as above includes both the transmitting and receiving PDCP/RLC entities. But in rapporteur’s understanding, it is not the fact. The detailed reasons are as below:

* For scenario 1 of section 2.1.1, if DCR is transmitted via unicast, UE\_2a will not establish the receiving PDCP/RLC entities based on the gray part of TS38.331 because UE\_2a may have no PC5-S message transmission requirement before DCR reception.
* For scenario 2 of section 2.1.2, if DCR is transmitted via broadcast, UE\_1 will establish the transmitting PDCP/RLC entities for SL-SRB0 using broadcast destination layer-2 ID. UE\_1 can’t establish the receiving PDCP/RLC entities for SL-SRB0 which carrying the DIRECT LINK AUTHENTICATION REQUEST message since it is transmitted via unicast and the UE\_1 does not know the source layer-2 ID used by UE\_2a.
* For scenario 3 of section 2.1.3, if DCR is transmitted via broadcast, UE\_1 will establish the transmitting PDCP/RLC entity for SL-SRB0 using broadcast destination layer-2 ID. UE\_1 can’t establish the receiving PDCP/RLC entities for SL-SRB1 which carrying the DIRECT LINK SECURITY MODE COMMAND message since it is transmitted via unicast and the UE\_1 does not know the source layer-2 ID used by UE\_2a.

**Question 2-3: Do companies agree that the description in the following table (copied from TS38.331) is only used to trigger the transmitting PDCP/RLC entities establishment for SL-SRB0/SL-SRB1/SL-SRB2, not for the receiving PDCP/RLC entities establishment for SL-SRB0/SL-SRB1/SL-SRB2?**

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| 5.8.9.1a.4            Sidelink SRB additionThe UE shall:1>  if transmission of PC5-S message for a specific destination is requested by upper layers for sidelink SRB:2>  establish PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-S message, as specified in sub-clause 9.1.1.4; |

## Candidate solutions

Based on the description in section 2.2, the problems of the current spec are summarized as below:

* Problem 1: The MAC filtering procedure for the first PC5-S unicast message described in scenario 1/2/3 has problem. The MAC can’t handle it properly. Hence, it will result that the receive MAC PDU will not be delivered to upper layer.
* Problem 2: The trigger for establishing the receiving PDCP/RLC entities at least for SL-SRB0/SL-SRB1/SL-SRB2 in TS38.331 are missing.

In order to fix the above two problems in current specs, there are two main methods:

* Alt 1: Resolve it in upper layer (SA2/CT1 scope);
* Alt 2: Resolve it in AS layer.

For Alt 1, the most direct method is that when upper layer sending the unicast PC5-S message before PC5-S connection setup to lower layer, it change the cast type from unicast to broadcast.

For Alt 2, there are mainly two methods:

* Alt 2.1: Add a note in section 5.8.1 of TS 38.331.

In the note, it can clarify that before PC-5 RRC connection setup, for SL-SRB0/SL-SRB1/SL-SRB2, no matter which cast type is indicated from upper layer, AS take its cast type as sidelink broadcast. One example CR is shown in annex B.

* Alt 2.2: Modify the MAC and RRC spec

In order to resolve the issues mentioned in section 2.2, the following modification on spec can be considered:

* + - For MAC:
			* Modify the spec to deliver the decoded MAC PDU to the disassembly and demultiplexing entity without check the SRC field of the TB if the received TB is the first unicast TB belonging to a logical channel which associated LCID is equal to 0 or 1 or 2.
			* MAC sends indicator to RRC to trigger the establishment of receiving PDCP/RLC entity for first SL-SRB0, SL-SRB1 and SL-SRB2 message reception.
		- For RRC, adding the trigger for establishing the receiving PDCP/RLC entities for SL-SRB0, SL-SRB1 and SL-SRB2 if needed.

One example CR is shown in annex A.

**Question 3-1a: If the issue in section 2.2 is confirmed, do companies prefer to resolve it in AS layer or upper layer?**

* + **Option 1: resolve it in upper layer**
	+ **Option 2: resolve it in AS layer**
	+ **Option 3: others (if any, please give the detailed description)**

**Question 3-1b: If the issue in section 2.2 is confirmed, do companies prefer to resolve it by changing the cast type or not?**

* + **Option 1: resolve it by changing the cast type from unicast to broadcast**
	+ **Option 2: resolve it without changing the cast type**

**Question 3-2: If companies prefer to resolve it in upper layer, which of the following option(s) is your preference?**

* **Option 1：When upper layer sending the unicast PC5-S message to lower layer before PC5-S connection setup, it change the cast type from unicast to broadcast.**
* **Option 2：Others (if any, please give the detailed description).**

**Question 3-3: If companies prefer to resolve it in AS layer, which of the following option(s) is your preference?**

* **Option 1：Resolve it via normative text**
* **Option 2：Resolve it by adding note(s) in spec**
* **Option 3: Others (if any, please give the detailed description).**

**Question 3-4: If Option 1 is selected in Question 3-3, regarding to the CR, which option do companies prefer?**

* **Option 1：Take annex A as baseline.**
* **Option 2: Others (if any, please give the detailed description on the impact spec, and how to do the change).**

**Question 3-5: If Option 2 is selected in Question 3-3, regarding to the CR, which option do companies prefer?**

* **Option 1：Take annex B as baseline.**
* **Option 2: Others (if any, please give the detailed description on the impact spec, and how to do the change).**

# Conclusion

In conclusion, rapporteur proposes the following recommendations as the outcome of this email discussion.

# References

1. R2-2110610 PDCP/RLC Entity Maintenance for SL-SRBs CATT, APPLE, vivo, Huawei, HiSilicon, OPPO
2. R2-2111429 Summary [AT116-e][709][V2X/SL] PDCP/RLC Entity Maintenance for SL-SRBs (CATT)

# Annex A Text proposals

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| START OF TP |

**Start of TP for 38.321**

##### 5.22.2.2.2 Sidelink process

For each PSSCH duration where a transmission takes place for the Sidelink process, one TB and the associated HARQ information is received from the Sidelink HARQ Entity.

For each received TB and associated Sidelink transmission information, the Sidelink process shall:

1> if this is a new transmission:

2> attempt to decode the received data.

1> else if this is a retransmission:

2> if the data for this TB has not yet been successfully decoded:

3> instruct the physical layer to combine the received data with the data currently in the soft buffer for this TB and attempt to decode the combined data.

1> if the data which the MAC entity attempted to decode was successfully decoded for this TB; or

1> if the data for this TB was successfully decoded before:

2> if this is the first successful decoding of the data for this TB:

3> if this TB is associated to unicast, the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Source Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI, and the SRC field of the decoded MAC PDU subheader is equal to the 16 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 8 LSB are equal to the Source ID in the corresponding SCI; or

3> if this TB is associated to groupcast or broadcast and the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI; or

3> if this TB is associated to unicast and this TB is the first TB of a logical channel which associated LCID is equals to 0 or 1 or 2, and the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Source Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI:

4> deliver the decoded MAC PDU to the disassembly and demultiplexing entity;

3> if this TB is associated to unicast and this TB is the first TB of a logical channel which associated LCID is equals to 0 or 1 or 2, and the DST field of the decoded MAC PDU subheader is equal to the 8 MSB of any of the Source Layer-2 ID(s) of the UE for which the 16 LSB are equal to the Destination ID in the corresponding SCI:

4> indicate RRC layer to trigger the reception of PC5-S message for a specific Source layer-2 ID.

**End of TP for 38.321**

**Start of TP for 38.331**

##### 5.8.9.1a.4 Sidelink SRB addition

The UE shall:

1> if transmission of PC5-S message for a specific destination is requested by upper layers for sidelink SRB:

2> establish the transmitting PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-S message, as specified in sub-clause 9.1.1.4;

1> if reception of PC5-S message for a specific source is requested by lower layers for sidelink SRB:

2> establish the receiving PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-S message if needed, as specified in sub-clause 9.1.1.4;

1> if a PC5-RRC connection establishment for a specific destination is indicated by upper layers:

2> establish PDCP entity, RLC entity and the logical channel of a sidelink SRB for PC5-RRC message of the specific destination, as specified in sub-clause 9.1.1.4;

2> consider the PC5-RRC connection is established for the destination.

**End of TP for 38.331**

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| END OF TP |

# Annex B Text proposals

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| START OF TP |

**Start of TP for 38.331**

## 5.8 Sidelink

### 5.8.1 General

NR sidelink communication consists of unicast, groupcast and broadcast. For unicast, the PC5-RRC connection is a logical connection between a pair of a Source Layer-2 ID and a Destination Layer-2 ID in the AS. The PC5-RRC signalling, as specified in sub-clause 5.8.9, can be initiated after its corresponding PC5 unicast link establishment (TS 23.287 [55]). The PC5-RRC connection and the corresponding sidelink SRBs and sidelink DRB(s) are released when the PC5 unicast link is released as indicated by upper layers.

For each PC5-RRC connection of unicast, one sidelink SRB (i.e. SL-SRB0) is used to transmit the PC5-S message(s) before the PC5-S security has been established. One sidelink SRB (i.e. SL-SRB1) is used to transmit the PC5-S messages to establish the PC5-S security. One sidelink SRB (i.e. SL-SRB2) is used to transmit the PC5-S messages after the PC5-S security has been established, which is protected. One sidelink SRB (i.e. SL-SRB3) is used to transmit the PC5-RRC signalling, which is protected and only sent after the PC5-S security has been established.

For unicast of NR sidelink communication, AS security comprises of integrity protection of PC5 signalling (SL-SRB1, SL-SRB2 and SL-SRB3) and user data (SL-DRBs), and it further comprises of ciphering of PC5 signaling (SL-SRB1 only for the Direct Link Security Mode Complete message as specified in TS 24.587[57], SL-SRB2 and SL-SRB3) and user data (SL-DRBs). The ciphering and integrity protection algorithms and parameters for a PC5 unicast link are exchanged by PC5-S messages in the upper layers as specified in TS 33.536 [60], and apply to the corresponding PC5-RRC connection in the AS. Once AS security is activated for a PC5 unicast link in the upper layers as specified in TS 33.536 [60], all messages on SL-SRB2 and SL-SRB3 and/or user data on SL-DRBs of the corresponding PC5-RRC connection are integrity protected and/or ciphered by the PDCP.

For unicast of NR sidelink communication, if the change of the key is indicated by the upper layers as specified in TS 24.587 [57], UE re-establishes the PDCP entity of the SL-SRB1, SL-SRB2, SL-SRB3 and SL-DRBs on the corresponding PC5-RRC connection.

NOTE 1: In case the configurations for NR sidelink communication are acquired via the E-UTRA, the configurations for NR sidelink communication in *SIB12* and *sl-ConfigDedicatedNR* within *RRCReconfiguration* used in subclause 5.8 are provided by the configurations in *SystemInformationBlockType28* and *sl-ConfigDedicatedForNR* within *RRCConnectionReconfiguration* as specified in TS 36.331 [10], respectively.

NOTE 2: In this release, there is one-to-one correspondence between the PC5-RRC connection and the PC5 unicast link as specified in TS 38.300[2].

NOTE 3: All SL-DRBs related to the same PC5-RRC connection have the same activation/deactivation setting for ciphering and the same activation/deactivation setting for integrity protection as in TS 33.536 [60].

NOTE 4: When integrity check failure concerning SL-SRB1 for a specific destination is detected, the UE sends an indication to the upper layers [57].

NOTE X: Before PC5-RRC connection establishment for a specific destination is indicated by upper layers, for PC5-S message using unicast, modify the cast type from unicast to broadcast.

**End of TP for 38.331**

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| END OF TP |