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| Technical Report | |
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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.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The scope of this Technical Report is to study and evaluate the possible architecture enhancements to the 5G Proximity-based Services (5G ProSe) system defined in TS 23.304 [3], based on the relevant Stage 1 requirements defined in TS 22.261 [4], TS 22.278 [5] and TS 22.115 [6] and determine which of the solutions can proceed to normative specifications.

This study will consider architecture enhancements in the following areas:

- Support of single NR PC5 hop UE-to-UE Relay for unicast;

- Enhancement of 5G ProSe UE-to-Network Relay functionality;

- Support of path switching between direct NR Uu communication path and direct NR PC5 communication path (i.e. non-relay case);

# 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 TR 23.752: "Study on system enhancement for Proximity based Services (ProSe) in the 5G System (5GS)".

[3] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".

[4] 3GPP TS 22.261: "Service requirements for next generation new services and markets; Stage 1".

[5] 3GPP TS 22.278: "Service requirements for the Evolved Packet System (EPS); Stage 1".

[6] 3GPP TS 22.115: "Service aspects; Charging and billing; Stage 1".

[7] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[8] 3GPP TS 23.502: "Procedures for the 5G System (5GS); Stage 2".

[9] 3GPP TS 22.101: "Service aspects; Service principles".[10] 3GPP TS 32.277: "Proximity-based Services (ProSe) charging".

[11] 3GPP TS 23.713: "Study on extended architecture support for proximity-based services".

[12] IETF RCF 4862: "IPv6 Stateless Address Autoconfiguration".

[13] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System".

[14] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification".

[15] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".

[16] 3GPP TS 23.237: "IP Multimedia Subsystem (IMS) Service Continuity; Stage 2".

[17] 3GPP TS 23.280: "Common functional architecture to support mission critical services; Stage 2".

[18] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)".

[19] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and TS 23.304 [3] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1] and TS 23.304 [3].

**5G ProSe U2U UE:** A 5G ProSe-enabled UE that discovers or is discovered by a 5G ProSe-enabled UE(s) via a 5G ProSe UE-to-UE Relay; or a 5G ProSe-enabled UE that communicates with other 5G ProSe-enabled UE(s) via a 5G ProSe UE-to-UE Relay.

**5G ProSe UE-to-UE Relay:** A 5G ProSe-enabled UE that provides functionality to support connectivity between 5G ProSe U2U UEs.

Editor's note: Terms related to UEs that are involved in UE-to-UE Relay operation need to be revisited and finalized.

## 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 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 TR 21.905 [1].

Abbreviation format (EW)

<ABBREVIATION> <Expansion>

# 4 Architecture Requirements and Assumptions

## 4.1 Architecture Requirements

Solutions shall build on the 5G ProSe architecture principles as defined in TS 23.304 [3] and 5G System architectural principles as defined in TS 23.501 [7], including flexibility and modularity for newly introduced functionalities.

In order to satisfy the normative stage-1 general requirements in TS 22.278 [5], TS 22.261 [4] and TS 22.115 [6], the system shall:

- support single NR PC5 hop UE-to-UE Relay for unicast.

- enhance UE-to-Network Relay functionality to support:

- service continuity when switching between two indirect network communication paths for UE-to-Network Relay;

- service continuity when switching between direct network communication path and indirect network communication path for 5G ProSe Layer-2 UE-to-Network Relay, including inter-gNB indirect-to-direct and inter-gNB direct-to-indirect path switching;

- multi-path transmission using only one direct network communication path and only one indirect network communication path e.g. for improved reliability or data rates;

- Emergency Services for Remote UE over UE-to-Network Relay.

- support path switching between direct NR Uu communication path and direct NR PC5 communication path;

NOTE 1: The UE-to-Network Relay and UE-to-UE Relay in this study include both Layer-3 and Layer-2 Relays unless explicitly stated.

NOTE 2: It is not targeted to support session continuity (e.g. IP address preservation) during path switching between direct NR Uu communication path and direct NR PC5 communication path.

## 4.2 Architecture Assumptions

- Architecture reference models defined in TS 23.304 [3] are used as basis architecture for supporting 5G ProSe Ph2.

- Architecture reference model defined in TS 23.501 [7] are used as basis architecture for supporting 5G ProSe Ph2.

- NG-RAN is considered; non-3GPP AN is not considered in this release.

- NR based PC5 and NR Uu are considered.

# 5 Key Issues

Editor's note: This clause will describe the key issues for the FS\_5G\_ProSe Ph2.

## 5.1 Key Issue #1: Support of UE-to-UE Relay

### 5.1.1 General description

This key issue intends to support single hop UE-to-UE Relay for unicast as illustrated in figure 5.1.1-1, including support for in coverage and out of coverage operation of Source UE, Target UE as well as the UE-to-UE Relay.



Figure 5.1.1-1: Example scenario of support of UE-to-UE Relay

At least the following aspects need to be studied in potential solutions:

- How to discover UE-to-UE Relay(s) and (re)-select a UE-to-UE Relay UE in proximity.

- Whether and how the network can control UE-to-UE Relay operation, at least including how to:

- Authorize the UE-to-UE Relay, e.g. authorize a UE as UE-to-UE Relay.

- Authorize Source/Target UEs to use a UE-to-UE Relay.

- Provisioning policy and parameters for UE-to-UE Relay service.

- How to establish the connection between the source UE and the target UE via UE-to-UE Relay.

- How to provide end-to-end QoS framework to satisfy the QoS requirements (such as data rate, reliability, latency).

- How to enhance the system architecture to provide security/privacy protection for a relayed connection.

- How to provide a mechanism for a path changing in case of e.g. UE-to-UE Relay changes, including reducing communication disruptions and fulfilling QoS requirements.

- Whether and how to determine whether Layer-2 UE-to-UE Relay or Layer-3 UE-to-UE Relay or both are supported by the Source, Target and Relay UEs and how to make sure the Source, Target and Relay UE all use the same type of relay.

NOTE 1: The solution should take into account the forward compatibility for supporting more than one hop in a later release.

NOTE 2: For the involvement of NG-RAN, coordination with RAN WGs is needed.

NOTE 3: For security/privacy protection aspects, coordination with SA WG3 is needed.

NOTE 4: This KI covers both Layer-2 and Layer-3 UE-to-UE relay cases.

## 5.2 Key Issue #2: Support of path switching between two indirect network communication paths for UE-to-Network Relaying with service continuity consideration

### 5.2.1 General description

This key issue intends to support the path switching between two indirect network communication paths for UE-to-Network Relaying with service continuity consideration.

This key issue should study whether all of the following path switching scenarios need to be considered and how:

- Layer-3 UE-to-Network Relay with N3IWF switching from/to Layer-3 UE-to-Network Relay with N3IWF.

- Layer-3 UE-to-Network Relay without N3IWF switching from/to Layer-3 UE-to-Network Relay without N3IWF.

- Layer-3 UE-to-Network Relay without N3IWF switching from/to Layer-3 UE-to-Network Relay with N3IWF.

- Layer-2 UE-to-Network Relay switching from/to Layer-2 UE-to-Network Relay.

- Layer-2 UE-to-Network Relay switching from/to Layer-3 UE-to-Network Relay without N3IWF.

- Layer-2 UE-to-Network Relay switching from/to Layer-3 UE-to-Network Relay with N3IWF.

It is understood that service continuity in different path switching cases can be achieved via application layer or session continuity. In this key issue, at least the following aspects need to be considered:

- What the triggers and criteria for path switching.

- How to select a UE-to-Network Relay for path switching.

- Identify the path switch procedure with service continuity consideration.

- Identify what the service continuity to be achieved for the solution in path switching.

NOTE: Coordination with RAN WGs is needed for RAN dependency.

## 5.3 Key Issue #3: Support direct communication path switching between PC5 and Uu (i.e. non-relay case)

### 5.3.1 General description

As illustrated in figure 5.3.1-1, the "direct communication path switching between PC5 and Uu reference points" refers to the procedure on how a UE switches between direct Uu communication path and direct PC5 communication path when it is communicating with another UE. The direct communication path over PC5 reference point means that the communication with another UE is performed by using 5G ProSe Direct Communication only. The direct communication path over Uu reference point means that the communication with another UE is performed via the network.



Figure 5.3.1-1: Example scenario of direct communication path switching between PC5 and Uu (i.e. switching between Figure a and Figure b)

When switching the path between the direct communication path over PC5 reference point and the direct communication path over Uu reference point, the ProSe service disruption to the UE should be minimized.

This key issue addresses the following:

- Whether and how to support path switching from direct NR Uu communication path to direct NR PC5 communication path or vice versa for both commercial and public safety services.

- How to support any IP, Ethernet or Unstructured PDU type for direct communication path switching.

- What functional entities and triggers are responsible for direct communication path switching and their impact on the corresponding interfaces. What information/policy are used for path switching decision.

- What are the procedures and potential impacts of direct communication path switching on QoS handling for direct PC5 communication path vs. direct Uu communication path?

NOTE: No RAN dependency is expected for key issue.

## 5.4 Key Issue #4: Support of path switching between direct network communication path and indirect network communication path for Layer-2 UE-to-Network Relay with session continuity consideration

### 5.4.1 General description

This key issue addresses how to enhance the 5GS to support the path switching between direct network communication path and indirect network communication path for Layer-2 UE-to-Network Relay, including inter-gNB indirect-to-direct and inter-gNB direct-to-indirect path switching.

When studying the above aspect, the following needs to be considered:

- What the triggers and criteria for path switching

- How to select a direct network communication path or an indirect communication path for path switching.

- How to perform the path switching with session continuity consideration.

NOTE: This key issue has strong dependency with RAN, and input from RAN WGs is needed to conclude.

## 5.5 Key Issue #5: Support of multi-path transmission for UE-to-Network Relay

### 5.5.1 General description

Multi-path transmission using only one direct network communication path and only one indirect network communication path with UE-to-Network Relay can be used to improve reliability or data rates for the Remote UE. As illustrated in figure 5.5.1-1, a UE can use path #1 and path #2 for multi-path transmission, where path #1 is direct network communication path, and path #2 is indirect network communication path with UE-to-Network Relay.



Figure 5.5.1-1: Example scenario of multi-path transmission using UE-to-Network Relay

At least the following aspects needs to be studied:

- Whether and how the network authorizes and the triggers for connection establishment for multi-path transmission, including:

- Whether and how to authorise a Remote UE to use the multi-path transmission for specific ProSe service(s).

- What information is required for and how does a Remote UE or UE-to Network Relay or the network trigger the multi-path connection establishment.

- How to provide/update the rules for multiple-path transmission.

- Whether and how to enhance the existing procedures to establish/modify/release a connection for multi-path transmission.

NOTE 1: Coordination with RAN WGs is needed for RAN dependency.

NOTE 2: For security aspects, coordination with SA WG3 is needed.

NOTE 3: This KI covers both Layer-2 and Layer-3 UE-to-Network Relay cases.

## 5.6 Key Issue #6: Support of PC5 Service Authorization and Policy/Parameter Provisioning

### 5.6.1 General description

Following scenarios need to be considered for this key issue:

- UE-to-UE Relay in KI#1;

- Multi-path transmission for UE-to-Network Relay in KI#5;

- Direct communication path switching between PC5 and Uu (i.e. non-relay case) in KI#3.

- Path switching between two indirect network communication paths for UE-to-Network Relaying in KI#2.

In order to enable PC5 service authorization and policy/parameter provisioning following aspects need to be studied:

- What are necessary enhancements for the procedures related to PC5 service authorization and policy/parameter provisioning to a UE, compared with what is currently specified in TS 23.304 [3] clause 5.1 and TS 23.502 [8] clause 4.2.2.2 (Registration Procedure), 4.2.4.3 (UE Configuration Update procedure for transparent UE Policy Delivery), 4.16.11 (UE Policy Association Establishment procedure), 4.16.12 (UE Policy Association Modification procedure).

- what are new information for PC5 service authorization and provisioning beyond what is currently specified in TS 23.304 [3] clause 5.1.

NOTE: Authorization and Provisioning as documented in TS 23.304 [3] clause 5.1 will be used as the baseline for this key issue.

## 5.7 Key Issue #7: Support of Emergency for UE-to-Network Relaying

### 5.7.1 General description

This key issue addresses how to Support of Emergency Services over UE-to-Network Relaying.

Per TS 22.101 [9], emergency service is defined as citizen to authority services, and it is left to the national authorities to decide whether the network accepts emergency calls e.g., for valid UE only, or for UEs without the SIM/USIM/ISIM.

In the 5G ProSe UE-to-Network relaying, if there is an emergency request from the remote UE, it implies that the Relay UE needs to be responsible for remote UE’s emergency service.

Assuming that a UE relaying emergency service for another UE is compliant with local regulation, this key issue is expected to address whether and how to address the following aspects for 5G ProSe UE-to-Network Relaying:

- Whether and how the UE-to Network Relay identifies the emergency services from the Remote UE and vice versa?

- Under which conditions can it be ensured that the emergency call is routed to PSAP of the same country as the Remote UE?

- What are UE and network behaviors and principles of operation for a Remote UE and 5G ProSe UE-to-Network Relay to be enhanced for the emergency services , below are some (but not limited) aspects:

- Overriding Mobility Restrictions when applicable as defined in TS 23.501 [7],

- Supporting emergency services in Limited service state as defined in clause 5.16.4, TS 23.501 [7],

- Supporting Congestion Control as defined in clause 5.19, TS 23.501 [7],

NOTE: Whether it is feasible to support all regulatory service requirements for Emergency Services over 5G ProSe UE-to-Network Relay is to be determined during the study.

Editor’s Note: The assumption that the 5G ProSe UE-to-Network Remote UE and 5G ProSe UE-to-Network Relay belong to the same PLMN needs to be validated by SA1.

Editor’s Note: Whether it can be assumed that a Relay UE may provide emergency service access to only one Remote UE at any time needs to be validated by SA1.

## 5.X Key Issue #X: <Key Issue Title>

### 5.X.1 General description

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Key Issues | | | | | | |
| Solutions | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | X |  |  |  |  |  |  |
| 2 | X |  |  |  |  |  |  |
| 3 | X |  |  |  |  |  |  |
| 4 | X |  |  |  |  |  |  |
| 5 | X |  |  |  |  |  |  |
| 6 | X |  |  |  |  |  |  |
| 7 | X |  |  |  |  |  |  |
| 8 | X |  |  |  |  | X |  |
| 9 | X |  |  |  |  |  |  |
| 10 | X |  |  |  |  |  |  |
| 11 | X |  |  |  |  |  |  |
| 12 | X |  |  |  |  |  |  |
| 13 | X |  |  |  |  |  |  |
| 14 |  | X |  |  |  |  |  |
| 15 |  | X |  |  |  |  |  |
| 16 |  |  | X |  |  | X |  |
| 17 |  |  | X |  |  |  |  |
| 18 |  |  | X |  |  |  |  |
| 19 |  |  | X |  |  |  |  |
| 20 |  |  | X |  |  |  |  |
| 21 |  |  | X |  |  |  |  |
| 22 |  |  | X |  |  |  |  |
| 23 |  |  |  | X |  |  |  |
| 24 |  |  |  | X |  |  |  |
| 25 |  |  |  |  | X | X |  |
| 26 |  |  |  |  | X |  |  |
| 27 |  |  |  |  | X |  |  |
| 28 |  |  |  |  | X |  |  |
| 29 |  |  |  |  | X |  |  |

## 6.1 Solution #1: UE-to-UE Relay Selection Without Relay Discovery

### 6.1.1 Description

This solution addressed Key Issue #1 “Support of UE-to-UE Relay”.

NOTE: The solution was Solution #8 of TR 23.752 [2].

When a source UE wants to communicate with a target UE, it will first try to find the target UE by either sending a Direct Communication Request or a Solicitation message with the target UE info. If the source UE cannot reach the target UE directly, it will try to discover a UE-to-UE relay to reach the target UE which may also trigger the relay to discover the target UE. To be more efficient, this solution tries to integrate target UE discovery and UE-to-UE relay discovery and selection together, including two alternatives:

- Alternative 1: UE-to-UE relay discovery and selection can be integrated into the unicast link establishment procedure as described in clause 6.4.3.1 of TS 23.304 [3].

- Alternative 2: UE-to-UE relay discovery and selection is integrated into Model B direct discovery procedure.

A new field is proposed to be added in the Direct Communication Request or the Solicitation message to indicate whether relays can be used in the communication. The field can be called relay\_indication. When a UE wants to broadcast a Direct Communication Request or a Solicitation message, it indicates in the message whether a UE-to-UE relay could be used. For Release 18, it is assumed that the value of the indication is restricted to single hop.

When a UE-to-UE relay receives a Direct Communication Request or a Solicitation message with the relay\_indication set, then it shall decide whether to forward the message (i.e. modify the message and broadcast it in its proximity), according to e.g. Relay Service Code if there is any, Application ID, authorization policy (e.g. relay for specific ProSe Service), the current traffic load of the relay, the radio conditions between the source UE and the relay UE, etc.

It may exist a situation where multiple UE-to-UE relays can be used to reach the target UE or the target UE may also directly receive the Direct Communication Request or Solicitation message from the source UE. The target UE may choose which one to reply according to e.g. signal strength, local policy (e.g. traffic load of the UE-to-UE relays), Relay Service Code if there is any or operator policies (e.g. always prefer direct communication or only use some specific UE-to-UE relays).

The source UE may receive the responses from multiple UE-to-UE relays and may also from the target UE directly, the source UE chooses the communication path according to e.g. signal strength or operator policies (e.g. always prefer direct communication or only use some specific UE-to-UE relays).

### 6.1.2 Procedures

#### 6.1.2.1 UE-to-UE relay discovery and selection is integrated into the unicast link establishment procedure (Alternative 1)



Figure 6.1.2.1-1 5G ProSe UE-to-UE relay selection (Alternative 1)

Figure 6.1.2.1-1 illustrates the procedure of the proposed method.

0. UEs are authorized to use the service provided by the UE-to-UE relays. UE-to-UE relays are authorized to provide service of relaying traffic among UEs. The authorization and the parameter provisioning can use solutions for KI#5. The authorization can be done when UEs/relays are registered to the network. Security related parameters may be provisioned so that a UE and a relay can verify the authorization with each other if needed.

1. UE-1 wants to establish unicast communication with UE-2 and the communication can be either through direct link with UE-2 or via a UE-to-UE relay. Then UE-1 broadcasts Direct Communication Request with relay\_indication enabled. The message will be received by relay-1, relay-2. The message may also be received by UE-2 if it is in the proximity of UE-1. UE-1 includes source UE info, target UE info, Application ID, as well as Relay Service Code if there is any. If UE-1 does not want relay to be involved in the communication, then it will made relay\_indication disabled.

NOTE 1: The data type of relay\_indication can be determined in Stage 3. Details of Direct Communication Request/Accept messages will be determined in stage 3.

2. Relay-1 and relay-2 decide to participate in the procedure. They broadcast a new Direct Communication Request message in their proximity without relay\_indication enabled. If a relay receives this message, it will just drop it. When a relay broadcasts the Direct Communication Request message, it includes source UE info, target UE info and Relay UE info (e.g. Relay UE ID) in the message and use Relay's L2 address as the source Layer-2 ID. The Relay maintains association between the source UE information (e.g. source UE L2 ID) and the new Direct Communication Request.

3. UE-2 receives the Direct Communication Requests from relay-1 and relay-2. UE-2 may also receive Direct Communication Request message directly from the UE-1 if the UE-2 is in the communication range of UE-1.

4. UE-2 chooses relay-1 and replies with Direct Communication Accept message. If UE-2 directly receives the Direct Communication Request from UE-1, it may choose to setup a direct communication link by sending the Direct Communication Accept message directly to UE-1. After receiving Direct Communication Accept, a UE-to-UE relay retrieves the source UE information stored in step 2 and sends the Direct Communication Accept message to the source UE with its Relay UE info added in the message.

After step 4, UE-1 and UE-2 have respectively setup the PC5 links with the chosen UE-to-UE relay.

NOTE 2: The security establishment between the UE1 and Relay-1, and between Relay-1 and UE-2 are performed before the Relay-1 and UE-2 send Direct Communication Accept message. Details of the authentication/ security establishment procedure are determined by SA WG3. The security establishment procedure can be skipped if there already exists a PC5 link between the source (or target) UE and the relay which can be used for relaying the traffic.

5. UE-1 receives the Direct Communication Accept message from relay-1. UE-1 chooses path according to e.g. policies (e.g. always choose direct path if it is possible), signal strength, etc. If UE-1 receives Direct Communication Accept / Response message request accept directly from UE-2, it may choose to setup a direct PC5 L2 link with UE-2 as described in clause 6.4.3.1 of TS 23.304 [3], then step 6 is skipped.

6a. For the L3 UE-to-UE Relay case, UE-1 and UE-2 finish setting up the communication link via the chosen UE-to-UE relay. The link setup information may vary depending on the type of relay, e.g. L2 or L3 relaying. Then UE-1 and UE-2 can communicate via the relay. Regarding IP address allocation for the source/remote UE, the addresses can be either assigned by the relay or by the UE itself (e.g. link-local IP address) as defined in clause 6.4.3.1 of TS 23.304 [3].

6b. For the Layer 2 UE-to-UE Relay case, the source and target UE can setup an end-to-end PC5 link via the relay. UE-1 sends a unicast E2E Direct Communication Request message to UE-2 via the Relay-1, and UE-2 responds with a unicast E2E Direct Communication Accept message to UE-1 via the Relay-1. Relay-1 transfers the messages based on the identity information of UE-1/UE-2 in the Adaptation Layer.

NOTE 3: How Relay-1 can transfer the messages based on the identity information of UE-1/UE-2 in the Adaptation Layer requires cooperation with RAN2 during the normative phase.

NOTE 4: In order to make a relay or path selection, the source UE can setup a timer after sending out the Direct Communication Request for collecting the corresponding response messages before making a decision. Similarly, the target UE can also setup a timer after receiving the first copy of the Direct Communication Request / message for collecting multiple copies of the message from different paths before making a decision.

NOTE 5: In the first time when a UE receives a message from a UE-to-UE relay, the UE needs to verify if the relay is authorized be a UE-to-UE relay. Similarly, the UE-to-UE relay may also need to verify if the UE is authorized to use the relay service. The verification details and the how to secure the communication between two UEs through a UE-to-UE relay is to be defined by SA WG3.

#### 6.1.2.2 UE-to-UE relay discovery and selection is integrated into Model B direct discovery procedure (Alternative 2)

Depicted in Figure 6.1.2.2-1 is the procedure for UE-UE Relay discovery Model B, and the discovery/selection procedure is separated from hop by hop and end-to-end link establishment.



Figure 6.1.2.2-1 5G ProSe UE-to-UE relay selection (Alternative 2)

1. UE-1 broadcasts discovery solicitation message carrying UE-1 info, target UE info (UE-2), Application ID, Relay Service Code if any, the UE-1 can also indicate relay\_indication enabled.

2. On reception of discovery solicitation, the candidate Relay UE-R broadcasts discovery solicitation carrying UE-1 info, UE-R info, Target UE info. The Relay UE-R uses Relay's L2 address as the source Layer-2 ID.

3. The target UE-2 responds the discovery message. If the UE-2 receives discovery solicitation message in step 1, then UE-2 responds discovery response in step 3b with UE-1 info, UE-2 info. If not and UE-2 receives discovery solicitation in step 2, then UE-2 responds discovery response message in step 3a with UE-1 info, UE-R info, UE-2 info.

4. On reception of discovery response in step 3a, UE-R sends discovery response with UE-1 info, UE-R info, UE-2 info. If more than one candidate Relay UEs responding discovery response message, UE-1 can select one Relay UE based on e.g. implementation or link qualification.

5. The source and target UE may need to setup PC5 links with the relay before communicating with each other. Step 5a can be skipped if there already exists a PC5 link between the UE-1 and UE-R which can be used for relaying. Step 5b can be skipped if there already exists a PC5 link between the UE-2 and UE-R which can be used for relaying.

6a. Same as step 6a described in clause 6.1.2.1.

6b. For the Layer-2 UE-to-UE Relay, the E2E unicast Direct Communication Request message is sent from UE1 to the selected Relay via the per-hop link (established in steps 5a) and the Adaptation layer info identifying the peer UE (UE3) as the destination. The UE-to-UE Relay transfers the E2E messages based on the identity information of peer UE in the Adaptation Layer. The initiator (UE1) knows the Adaptation layer info identifying the peer UE (UE3) after a discovery procedure. UE3 responds with E2E unicast Direct Communication Accept message in the same way.

NOTE 1: For the Layer 2 UE-to-UE Relay case, whether step5b is performed before step 6b or triggered during step 6b will be decided at normative phase.

NOTE 2: How Relay-1 can transfer the messages based on the identity information of UE-1/UE-2 in the Adaptation Layer requires cooperation with RAN2 during the normative phase.

### 6.1.3 Impacts on services, entities and interfaces

UE impacts to support new Relay related functions.

## 6.2 Solution #2: ProSe 5G Layer-3 UE-to-UE Relay based on IP routing

### 6.2.1 Description

This solution addressed Key Issue #1 “Support of UE-to-UE Relay”.

NOTE 1: The solution was Solution #10 of TR 23.752 [2].

In this solution, the ProSe 5G UE-to-UE Relay operations is supported with the following principles:

- Authorization and configuration:

- Only the UE authorized by the service authorization configuration can act as a ProSe 5G UE-to-UE Relay. These UEs will be configured according to the service authorization and provisioning mechanism defined in TS 23.304 [3] to operate in the UE-to-UE Relay mode.

- ProSe 5G UE-to-UE Relay discovery:

- The ProSe 5G UE-to-UE Relay sends out a Relay Discovery message periodically, announcing its availability for serving other UEs in the area.

- The ProSe 5G UE-to-UE Relay also supports the query and response mode for discovery. The ProSe 5G UE-to-UE Relay listens on a configured Layer-2 ID for the query, and would respond with its address and corresponding information to enable to other UE to establish a unicast connection with it. This process is similar to the unicast L2 link establishment procedure as defined in clause 6.4.3.1 of TS 23.304 [3].

NOTE 2: The Layer-2 ID used for the discovery can be specific for UE-to-UE Relay discovery, or shared with other discoveries, e.g. UE-to-Network Relay discovery.

- ProSe 5G UE-to-UE Relay operation:

- Any UE that wants to make use of the ProSe 5G UE-to-UE Relay needs to establish a unicast L2 link with the UE-to-UE Relay, with IP configuration. The ProSe 5G UE-to-UE Relay allocates IP address/prefix to the other UEs.

- As part of the unicast L2 link establishment procedure, the ProSe 5G UE-to-UE Relay stores an association of the User Info of the peer UE of the unicast link (or ProSe Service provided by the peer UE) and the IP address/prefix allocated to the UE into its DNS entries. The ProSe 5G UE-to-UE Relay acts as a DNS server to other UEs.

- When a (source) UE needs to communicate with another (target) UE or needs to discover a ProSe service via the ProSe 5G UE-to-UE Relay, it sends a DNS query for the target UE (based on Target User Info) or for the ProSe Service to the ProSe 5G UE-to-UE Relay over the unicast link, which will return the IP address/prefix of the target UE or the IP address(es)/prefix(es) of UEs which provide the ProSe Service.

If there are multiple UEs supporting the same ProSe Service, the (source) UE can select a UE(s) based on UE implementation.

- The source UE sends the IP data or non-IP data encapsulated in IP to the target UE or to the selected UE(s) which provide(s) the ProSe Service via the unicast L2 link to UE-to-UE Relay that returned the IP address/prefix of the target UE or UE(s) which provide(s) the ProSe Service. The ProSe 5G UE-to-UE Relay acts as an IP router, and forwards the packets to the corresponding unicast L2 link towards the target UE or UE(s) which provide(s) the ProSe Service. Each of the unicast L2 link is treated as an IP interface.

- If there are multiple ProSe 5G UE-to-UE Relays in the proximity, UE can choose either one or more ProSe 5G UE-to-UE Relays to establish the unicast L2 link based on UE implementation. For example, the UE sends a DNS query on each of the unicast L2 link to the ProSe 5G UE-to-UE Relays. Then, the source UE may choose to use the first ProSe 5G UE-to-UE Relay that returns a positive DNS query for the target UE.

NOTE 3: The selection of the UE-to-UE Relay may be based on local configured rules on the UE, or based on other discovery solutions, e.g. "Stateful UE-to-UE Relay" described in clause 6.3.

- QoS handling:

- When the source UE establishes the unicast L2 link with the ProSe 5G UE-to-UE Relay, it can establish corresponding PC5 QoS Flows according to procedure defined in clause 6.4.3.1 of TS 23.304 [3]. It can also modify the PC5 QoS Flows at any time using procedure defined in clause 6.4.3.4 of TS 23.304 [3].

- Correspondingly, the ProSe 5G UE-to-UE Relay can also establish and modify the PC5 QoS Flows using the above-mentioned procedures over the unicast L2 Link with the target UE based on PC5 Packet Filter received from the source UE during the PC5 QoS flow establishment/modification procedure or destination IP address of IP packet received from the source UE for the forwarding of source UE's traffic. The ProSe 5G UE-to-UE Relay determines the PC5 QoS parameters of PC5 QoS Flows with target UE based on corresponding PC5 QoS Flows with target UE.

- Security handling:

- source UE and target UE can establish bearer level security with the UE-to-UE Relay for the unicast L2 Link, using procedures defined in TS 23.304 [3].

- If end-to-end security protection is required between source UE and target UE, IPSec can be used.

NOTE 4: The security protection of the traffic of source UE and target UE will be specified by SA WG3.

- Charging Support:

- ProSe 5G UE-to-UE Relay can follow the charging solution defined in TS 32.277 [10] to report the source and target UEs and corresponding traffic to the charging function.

### 6.2.2 Procedures



Figure 6.2.2-1: 5G ProSe UE-to-UE Relay operation

Figure 6.2.2-1 provides an example operation for the 5G ProSe UE-to-UE Relay operation based on standard IP operation.

### 6.2.3 Impacts on services, entities and interfaces

There is no impact to NG-RAN, as the solution is using the existing features supported in Rel-16 NR V2X design.

UEs operate with existing IP operation, and the ProSe 5G UE-to-UE Relay supports the IP router function (for IP address allocation and traffic forwarding) and the functionality of a DNS server.

## 6.3 Solution #3: Stateful UE-to-UE Layer-2 or Layer-3 Relay for Public Safety

### 6.3.1 Introduction

The solution applies to Key Issue #1 "Support of UE-to-UE Relay".

NOTE: The solution was Solution #11 of TR 23.752 [2].

The procedure for discovery of UE-to-UE Relay in this solution is based on TR 23.713 [11] clause 6.1.2.4.

The communication via the stateful UE-to-UE Relay can be performed at either Layer-3 (6.3.3.2.2) or at Layer-2 (refer to clause 6.3.3.2.3).

### 6.3.2 Functional Description

In reference to Figure 6.3.2-1, the UE-to-UE Relay (UE-R) is a logical functionality that assists a UE (e.g. UE-1) to discover its group members (e.g. UE-2) which may not be reachable directly over NR PC5, but each of which is reachable via the UE-to-UE Relay. Once the UE discovers other group member UEs that are reachable via the UE-to-UE Relay, it can engage in communication with them, the UE-to-UE Relay acting as a Layer-3 relay.



Figure 6.3.2-1: Stateful UE-to-UE Relay

The UE-to-UE Relay performs the following functionality:

- Group Member Discovery using Model A or Model B discovery as defined in TS 23.304 [3].

- UE-to-UE Relay Discovery using the procedures defined in clause 6.3.3.1.

- Acting as Layer-3 relay for communication between UEs using the procedures defined in clause 6.3.3.2.

### 6.3.3 Procedures

#### 6.3.3.1 UE-to-UE Relay discovery

##### 6.3.3.1.1 Model A

Depicted in figure 6.3.3.1.1-1 is the procedure for UE-to-UE Relay discovery Model A.



Figure 6.3.3.1.1-1: UE-to-UE Relay discovery with Model A

1. UE-1 ("this UE") performs the Group Member Discovery procedure (either Model A or Model B) as defined in TS 23.304 [3]. In the process UE-1 discovers UE-R as its only neighbour.

2. UE-R ("the potential relay") also performs the Group Member Discovery procedure (either Model A or Model B). In the process UE-R discovers two UEs in vicinity: UE-1 and UE-2.

NOTE 1: The execution of the Group Member Discovery procedure in steps 1 and 2 is a pre-requisite for the execution of the UE-to-UE Relay discovery procedure proper that only starts at step 3. Each of the UEs periodically performs the Group Member Discovery procedure in order to keep an up-to-date list of the neighbouring UEs that are directly reachable via NR PC5.

3. UE-R decides that it can act as a UE-to-UE Relay and announces this by periodically transmitting an Announcement message including the following parameters:

- Type = Announcement.

- Discovery Type = UE-to-UE Relay Discovery.

- Announcer Info (i.e. an upper layer identifier for the UE-R user).

- ProSe UE ID of UE-R (i.e. Layer-2 identifier of UE-R).

- A list of "Target User Info" parameters (including users of UE-1 and UE-2) that have been gathered during Group Member Discovery in step 2. "Target User Info" is an upper layer parameter identifying the target user. To support Layer-2 communication via the stateful UE-to-UE Relay, the "Target User Info" also includes the Layer-2 identifier of the target user's UE.

4. Based on the information received in the previous step, UE-1 decides to establish a one-to-one communication link with UE-R and engage in communication with UE-2 via UE-R, as described in clause 6.3.3.2.

##### 6.3.3.1.2 Model B

Depicted in figure 6.3.3.1.2-1 is the procedure for UE-UE Relay discovery Model B.



Figure 6.3.3.1.2-1: UE-to-UE Relay discovery with Model B

1-2. These steps are identical to steps 1-2 in Figure 6.3.3.1.1-1.

NOTE: The execution of the Group Member Discovery procedure in steps 1 and 2 is a pre-requisite for the execution of the UE-to-UE Relay discovery procedure proper that only starts at step 3. Each of the UEs periodically performs the Group Member Discovery procedure in order to keep an up-to-date list of the neighbouring UEs that are directly reachable via NR PC5.

3. Having discovered its neighbours, UE-1 realises that the group member of interest ("target user") is not within direct range over NR PC5. UE-1 then (in the role of Discoverer) solicits potential UE-to-UE Relays by transmitting the Solicitation message including the following parameters:

- Type = Solicitation.

- Discovery Type = UE-to-UE Relay Discovery.

- Discoverer Info (i.e. an upper layer identifier for the UE-1 user).

- ProSe UE ID of UE-1 (i.e. layer-2 identifier of UE-1).

- A list of "Target User Info" parameters corresponding to the target user(s) of interest (in this case it is the user of UE-2). "Target User Info" is an upper layer parameter identifying the "target user" of interest.

4. Upon reception of the Solicitation message, UE-R (in the role of Discoveree) realises that it can act as a UE-to-UE Relay and replies with a Response message including the following parameters:

- Type = Response.

- Discovery Type = UE-to-UE Relay Discovery.

- Discoveree Info (i.e. an upper layer identifier for the UE-R user).

- ProSe UE ID of UE-R (i.e. layer-2 identifier of UE-R).

- A list of "Target User Info" parameters corresponding to the target user(s) of interest (in this case it is the user of UE-2). The latter have been gathered during Group Member Discovery in step 2. To support Layer-2 communication via the stateful UE-to-UE Relay, the "Target User Info" also includes the Layer-2 identifier of the target user's UE.

5. Based on the information received in the previous step, UE-1 decides to establish a one-to-one communication link with UE-R and engage in communication with UE-2 via UE-R, as described in clause 6.11.3.2.

#### 6.3.3.2 Communication via the stateful UE-to-UE Relay

##### 6.3.3.2.1 General

The communication via the stateful UE-to-UE Relay can be performed at either Layer-2 or Layer-3.

##### 6.3.3.2.2 Communication via stateful Layer-3 UE-to-UE Relay

When the communication via the stateful UE-to-UE Relay is performed at layer-3, the simplified Layer-2 format for ProSe 5G communication is decpited in Figure 6.3.3.2.2-1.



Figure 6.3.3.2.2-1: Layer-2 frame format for ProSe 5G communication via Layer-3 UE-to-UE Relay

When UE1 sends a packet to UE2 via the Relay, in reference to Figure 6.3.3.2.2-1 the fields in the Layer-2 header are ste as follows:

- Source Layer-2 ID: Identifies the sender of the data (UE-1).

- Destination Layer-2 ID: Identifies the Relay (UE-R).

The final destination (i.e. UE-2) is identified via the Destination IP address in the IP packet header.

NOTE: The Layer-2 frame in Figure 6.3.3.2.2-1 is a high-level illustration of the required addressing functionality in Layer-2 header. The exact Layer-2 frame format is in the scope of RAN WGs.

The procedures for communication via the stateful UE-to-UE Layer-3 Relay are performed at layer-3 as described in clause 6.2, the stateful UE-to-UE Relay acting as an IP router.

##### 6.3.3.2.3 Communication via stateful Layer-2 UE-to-UE Relay

When the communication via the stateful UE-to-UE Relay is performed at layer-2, the Layer-2 frame header is used as illustrated in Figure 6.3.3.2.3-1. In addition to the Source Layer-2 ID and Destination Layer-2 ID fields, the header has in addition a "Relay Layer-2 ID" field and a "Direction" field:

- "Relay Layer-2 ID": identifies the UE-to-UE Relay.

- "Direction" indicates whether the Layer-2 frame is being transmitted "To the Relay" or "From the Relay".



Figure 6.3.3.2.3-1: Extended Layer-2 frame format for ProSe 5G communication via Layer-2 UE-to-UE Relay

When UE-1 wishes to send data to UE-2 via UE-R, the addressing identifiers in the Layer-2 frame are set as follows:

- Source Layer-2 ID: identifies UE-1.

- Destination Layer-2 ID: identifies UE-2.

- Relay Layer-2 ID: identifies the Relay (UE-R).

- Direction = "To Relay".

When UE-R forwards the Layer-2 frame to UE-2, the addressing identifiers in the Layer-2 frame are set as follows:

- Source Layer-2 ID: identifies UE-1.

- Destination Layer-2 ID: identifies UE-2.

- Relay Layer-2 ID: identifies UE-R.

- Direction = "From Relay".

NOTE1: The Layer-2 frame in Figure 6.3.3.2.3-1 is a high-level illustration of the required addressing functionality in Layer-2 header. The exact Layer-2 frame format is in the scope of RAN WGs.

NOTE2: The "Direction" field is used by the final receiver (UE-2) to eliminate duplicate frames in case UE-2 enters in direct transmission range of UE-1.

### 6.3.4 Impacts on services, entities and interfaces

**UE:**

- New functionality related to UE-to-UE Relay discovery, as well as communication via UE-to-UE Relay.

## 6.4 Solution #4: QoS control for UE-to-UE Relay

### 6.4.1 Description

This is a solution for Key Issue #1, UE-to-UE Relay. This solution is applicable for both Layer 2 UE-to-UE Relay and Layer 3 UE-to-UE Relay.

NOTE: The solution was Solution #31 of TR 23.752 [2].

When a source UE wants to establish unicast communication with a target UE, the source UE will decide the E2E QoS parameters between source UE and target UE based on the application layer requirements. The E2E QoS parameters, especially the PDB, needs to be split between the two PC5 interface. The PER of the two PC5 interfaces also needs to be set properly to achieve the PER target in the E2E QoS parameters.

Relay will split the E2E QoS parameters into two parts: one part is the QoS parameters between source UE and Relay (we call it "Source side PC5 QoS parameters"), the other part is the QoS parameters between Relay and the target UE (we call it "Target side PC5 QoS parameters").

When standardized PQI is used, the Source side PC5 QoS parameters and the Target side PC5 QoS parameters include PQI and other optional QoS parameters, e.g. GFBR. When non-standardized PQI is used, the whole set of PC5 QoS characteristics is also included.

Relay ensures the PDB and PER associated with the PQI in the Source side PC5 QoS parameters and the PDB and PER associated with the PQI in the Target side PC5 QoS parameters supports the E2E PDB requirements between Remote UE and target UE. Relay also ensures other QoS parameters/QoS characteristics in the Source side PC5 QoS parameters and Target side PC5 QoS parameters are compatible, e.g. have the same value. The Relay decision may be based on the local policy or the low layer measurement.

Optionally, it's possible that the source UE is pre-configured with authorized service(s) and the related Source side PC5 QoS parameters, the UE-to-UE Relay is pre-configured with authorized service(s) and the related Target side PC5 QoS parameters. These can be provided by PCF during provisioning procedure. The authorized service can be identified by Relay Service Code etc. With the preconfigured QoS parameters, the source UE provides the Source side PC5 QoS parameters to the UE-to-UE Relay by the procedure defined in TS 23.304 [3] clause 6.4.3.1 or clause 6.4.3.4, then the UE-to-UE Relay identifies the authorized service and establishes the corresponding PC5 QoS Flows with the Target UE using the preconfigured Target side PC5 QoS parameters.

E2E QoS parameters splitting is common for both Layer 2 UE-to-UE Relay and Layer 3 UE-to-UE Relay. The difference lies in the QoS flow. In the Layer 3 UE-to-UE Relay case, two QoS flows are setup, one QoS flow between Source UE and UE-to-UE Relay UE, and another QoS flow between Source UE and UE-to-UE Relay UE. In the Layer 2 UE-to-UE Relay case, the end-to-end QoS flow is setup between the Source UE and the Target UE.

### 6.4.2 Procedures for Layer 3 UE-to-UE Relay



Figure 6.4.2-1: QoS control for Layer 3 UE-to-UE Relay

1. Source UE wants to establish unicast communication with target UE, it decides the E2E QoS parameters between source UE and target UE based on the application layer requirements. The Source UE sets up a PC5 QoS Flow with PFI=PFI\_s. Then Source UE provides the PFI\_s, E2E QoS parameters, source and target user info to UE-to-UE Relay. The process is similar to the unicast L2 link establishment or modification procedure as defined in TS 23.304 [3] clause 6.4.3.

2. Relay splits the E2E QoS parameters into two parts: one part is for the PC5 interface between source UE and Relay, the other part is for the PC5 interface between Relay and the target UE. Relay will setup a PC5 QoS Flow with PFI=PFI\_t using the target side PC5 QoS parameters between Relay and the target UE.

3. Relay provides the PFI\_t, target side PC5 QoS parameters, source and target user info to target UE. The process is similar to the unicast L2 link establishment or modification procedure as defined in TS 23.304 [3] clause 6.4.3.

4. Relay receives the Layer-2 link establishment/modification accept from target UE.

5. Relay provides the Layer-2 link establishment/modification accept to the source UE with the PFI\_s and the source side PC5 QoS parameters.

The data transfer on Layer 3 UE-to-UE Relay is according to traffic filter on both hops.

### 6.4.3 Procedures for Layer 2 UE-to-UE Relay



Figure 6.4.3-1: QoS control for Layer 2 UE-to-UE Relay

0. When the Source UE wants to communication with the target UE, it uses the extended unicast link defined in Solution#9 of TR 23.752 [2], and the Source UE decides the E2E QoS parameters between Source UE and Target UE based on the application layer requirements. The Source UE sets up a PC5 QoS Flow with PFI, similar to the 5G ProSe mechanism defined in clause 6.4.3.1 of TS 23.304 [3], the Source UE negotiates the information about PC5 QoS Flow, which includes the PFI, the corresponding E2E PC5 QoS parameters and the associated application info, with the Target UE in step 0a and step 0b. In this step, E2E PC5-S messages are used for E2E QoS negotiation, and the UE-to-UE Relay just transfers the E2E PC5-S messages using the RAN specified L2 relay method.

NOTE: The PC5-S messages used in step 0 are the E2E PC5-S messages transferred between the Source UE and the Target UE and the PC5-S messages used in step 1 to step 5 are the per-hop PC5-S messages transferred between the Source UE or the Target UE and the UE-to-UE Relay.

1. After the E2E QoS parameter negotiation in step 0a and step 0b, the Source UE provides the PFI, E2E QoS parameters, source and target user info to UE-to-UE Relay. The process is similar to the unicast L2 link establishment or modification procedure as defined in TS 23.304 [3] clause 6.4.3.

2. Relay splits the E2E QoS parameters into two parts: one part is for the PC5 interface between source UE and Relay (source side PC5 QoS parameters), the other part is for the PC5 interface between Relay and the target UE (target side PC5 QoS parameters).

3. Relay provides the PFI received from source UE, target side PC5 QoS parameters, source and target user info to target UE. The process is similar to the unicast L2 link establishment or modification procedure as defined in TS 23.304 [3] clause 6.4.3.

4. Relay receives the Layer-2 link establishment/modification accept from target UE.

5. Relay provides the Layer-2 link establishment/modification accept to the source UE with the PFI and the source side PC5 QoS parameters.

After the PC5 QoS parameters splitting for two PC5 links, the AS layer configurations for PC5 QoS parameters in each of the PC5 links can be achieved according to legacy mechanisms in Rel-17 5G ProSe (TS 23.304 [3]). For the QoS enforcement, the UE-to-UE Relay UE performs the necessary adaptation in the AS layers of the two PC5 interfaces, and it transfers the received data based on the adaptation in the AS layer.

Editor's note: How to ensure the PC5 QoS over the two PC5 links by the Adaptation Layer, and the functionalities of the Adaptation Layer will be confirmed by RAN WG2.

If the Source UE or Target UE wants to add, remove or modify a QoS flow on the extended unicast link, the link modification procedure defined in clause 6.4.3.4 of TS 23.304 [3] can be used, where the Link Modification Request message is the E2E PC5-S message.

### 6.4.4 Impacts on services, entities and interfaces

- UE-to-UE Relay supports the E2E QoS parameters splitting between the two PC5 interfaces.

## 6.5 Solution #5: Support Layer-3 UE-to-UE Relay Based on IPv6 link-local addresses

### 6.5.1 Description

This solution addressed Key Issue #1 “Support of UE-to-UE Relay”.

NOTE 1: The solution was Solution #32 of TR 23.752 [3].

The basic idea of the solution is when a UE establishes a connection with a UE-to-UE relay, it uses its link-local IPv6 address as its IPv6 address and informs to the relay UE. The relay UE maintains a mapping between link-local IPv6 addresses to UE IDs (e.g. Application Layer IDs), as well as mapping from an Application User ID to a PC5 unicast link.

The solution is based on the following assumptions:

1. A source UE establishes a unicast link to a relay UE for communicating with target UEs which connects to that relay UE.

2. For a specific source UE, the traffic to target UEs through the same relay UE can share the same unicast link to that relay UE.

3. When the relay UE receives a packet from a source or target UE, it forwards the packet to an PC5 unicast link according to the destination IP address in the packet.

### 6.5.2 Procedures

In this clause, UE-1 and UE-2 are the source and target UEs, respectively. Relay-1 is a Layer-3 UE-to-UE relay.

#### 6.5.2.1 Relay path establishment procedure

Step 1. UE-1 and UE-2 do the relay selection. In this step, any solution for UE-to-UE relay selection can be applied here, e.g. solution#1.

Step 2. UE-1 and UE-2 establish individual unicast link to Relay-1, if they do not have unicast link with the relay for the UE-to-UE relaying communication use case.

UE forms its own link-local IPv6 address based on IETF RFC 4862 [12] and informs the IP address to the relay UE. Relay UE maintains a mapping between the UE ID (e.g. Application Layer ID) and the link-local address.

NOTE: If the link-local IP address of UE-1 or UE-2 is conflicting with the link-local IP address of another remote UE that has already connected to the relay UE, the relay shall inform UE-1 or UE-2 to change its link-local IP address, e.g. using the address duplicate detection procedure defined in IETF RCF 4862 [12].

Step 3. If UE-1 does not know the IP address of UE-2, it sends a request to the relay UE, asking the IP address of UE-2. The request includes the UE-2 ID, e.g. the Application Layer ID. Relay-1 gives the link-local IP address of UE-2 to UE-1. UE-2 does the same procedure if it does not know the IP address of UE-1.

Step 4. UE-1 and UE-2 can communicate with each other via Relay-1.

When the remote UEs change Layer-3 UE-to-UE relay, they can keep their link-local IP addresses. The old UE-to-UE relay shall remove the mapping between the link-local IP address and the remote UE.

Editor's note: Whether and how to support periodic change of the link-local IP address due to privacy requirement is FFS and co-ordinated with SA WG3 group.



Figure 6.5.2.1-1 UE-1 communicates with UE-2 via Layer-3 UE-to-UE relay

#### 6.5.2.2 Path switch from one UE-to-UE relay to another UE-to-UE relay

The following procedure depicts the scenario that UE-1 and UE-2 changes the UE-to-UE relay from Relay-1 to Relay-2.



Figure 6.5.2.2-1 UE-1 and UE-2 change the communication path from the path via Relay-1 to the path via Relay-2

Step1. One of the remote UE detects the current UE-to-UE communication path is not good enough or some other event triggers relay re-selection, so the relay re-selection is executed.

NOTE 1: The reselection trigger for UE-2 can be based on, for example, application layer trigger or based on current relay conditions.

Step2. Any UE-to-UE (re)selection solution for Layer-3 UE-to-UE relay can be applied here, and Relay-2 is selected as the new relay by UE-1 and UE-2.

Step3. UE-1 and UE-2 establish unicast link individually to Relay-2. The UE-1 and UE-2 keep their link-local addresses and inform the IP addresses to the Relay-2. Relay-2 maintains a mapping between the UE IDs (e.g. Application Layer IDs) and the link-local addresses.

This step can be skipped if the remote UE already has a unicast link with the same link-local IPv6 address to Relay-2.

Step4. UE-1 and UE-2 send an end marker through the old path to each other, indicating that they start sending traffic via the new path.

NOTE 2: The UEs can wait for a predetermined period until the end marker is received from each other before switching to new path. Such details are to be developed during stage 3 work.

Step5. UE-1 and UE-2 can communicate with each other via Relay-2.

### 6.5.3 Impacts on services, entities and interfaces

The solution impacts the relay UE to support IP packets forwarding between remote UEs.

## 6.6 Solution #6: Support Layer-3 UE-to-UE Relay to Handle Non-IP Traffic

### 6.6.1 Description

#### 6.6.1.1 General

This solution addressed Key Issue #1 “Support of UE-to-UE Relay”.

NOTE: The solution was Solution #49 of TR 23.752 [3].

The user plane protocol stack assumed in this contribution is illustrated by Figure 6.6.1.1-1. Since there is no IP headers in the Non-IP packets, the UE-to-UE relay cannot use destination IP addresses to forward the packets, In this solution, the UE-to-UE relay uses the Layer-2 IDs in the incoming Layer-2 frames to find the correct outgoing PC5 links. Basically, the solution is based on the following principles:

1. For a specific source UE, it establishes a PC5 link for Non-IP traffic with the UE-to-UE relay for each target UE it wants to communicate via that relay. This principle means that the Non-IP traffic to different target UEs from the same source UE cannot share the same PC5 link between the source UE and the UE-to-UE relay.

2. For each pair of source and target UEs, the UE-to-UE relay assigns itself a Layer-2 ID, denoted as L2-ID\_R, which is used in the Non-IP PC5 link to the source UE and the Non-IP PC5 link to the target UE. The UE-to-UE relay maintains a mapping between L2-ID\_R and a pair of source and target UEs. The source and target UEs store the mapping information when establishing relay path between the source and target UEs via the UE-to-UE relay. When the source and target UEs send Non-IP traffic to each other via the UE-to-UE relay, they use L2-ID\_R as the destination Layer-2 ID. When the UE-to-UE relay receives a packet, according to the L2-ID\_R and the source L2-ID it can forward the packet to the correct PC5 link based on the mapping, it also changes the destination L2-ID from L2-ID\_R to the correct Layer2 ID of the target UE. The source and target UEs identify the original UE when receiving packets from the UE-to-UE relay according to the mapping information.



Figure 6.6.1.1-1: User plane protocol stack of PC5 when using Layer-3 UE-to-UE relay to forward Non-IP traffic

#### 6.6.1.2 QoS handling

Regarding QoS handling, solution #4 is adopted to achieve end-to-end QoS control via UE-to-UE relay. Basically, for a specific PC5 QoS flow, say PFI\_s, in the Non-IP PC5 link with the source UE, the UE-to-UE relay maps it to a specific PC5 QoS flow, say PFI\_t, in the Non-IP PC5 link with the target UE. Incoming traffic from one of the flows is forwarded by the UE-to-UE relay to the other flow.

#### 6.6.1.3 Security

For end-to-end security, IPsec cannot be used, since it is not IP traffic. It is up to the application to implement end-to-end security for non-IP traffic.

Editor's note: How to handle end-to-end security for Non-IP traffic is FFS and shall be co-ordinated with SA WG3 group.

### 6.6.2 Procedures

#### 6.6.2.1 Relay path establishment procedure

Figure 6.6.2.1-1 illustrates the procedure of path establishment procedure for Non-IP traffic communication via a Layer-3 UE-to-UE relay.

0. Source UE and target UE do the relay selection. In this step, any solution for UE-to-UE relay selection can be applied here.

1. Source UE wants to start Non-IP communication with the target UE. It starts to establish a PC5 unicast link with the relay by sending a Direct Communication Request to the relay as defined in clause 6.4.3.1 of TS 23.304 [3]. In the request, the source UE indicates that the PC5 link is used for Non-IP communication to the target UE.

Editor's note: It is FFS if traffic type, e.g. IP or Non-IP, can be derived from the ProSe Application ID.

2. The UE-to-UE relay assigns itself a Layer-2 ID, denoted as L2-ID\_R, which is used in the Non-IP PC5 link to the source UE and the Non-IP PC5 link to the target UE. The UE-to-UE relay creates the mapping between the L2-ID\_R and the pair of UEs.

3. UE-to-UE relay sends a Direct Communication Request to the target UE, indicating that the link is used for Non-IP communication with the source UE. It also provides the mapping information in the request.

4. Target UE and the UE-to-UE relay setup security for the PC5 link.

NOTE: Whether L2-ID\_R is provided in step 3 or step 4 is coordinated with SA WG3.

5. Target UE stores the mapping information, and sends Direct Communication Accept.

6. UE-to-UE relay and the source UE setup security for the PC5 link.

7. UE-to-UE relay sends Direct Communication Accept with L2-ID\_R and provides the mapping information. The resource UE stores the mapping information.

8. Non-IP communication between the source and the target UE via the relay. When the source and target UEs send Non-IP traffic to each other via the UE-to-UE relay, they use L2-ID\_R as the destination L2-ID. When the UE-to-UE relay receives a packet, according to the L2-ID\_R and the original UE L2-ID it can forward the packet to the correct PC5 link based on the mapping between the L2-ID\_R and the pair of UEs, it also changes the destination L2-ID from L2-ID\_R to the correct L2-ID of the destination UE. The source and target UEs identify the original UE when receiving packets from the UE-to-UE relay according to the local stored mapping information.



Figure 6.6.2.1-1 Path establishment procedure for Non-IP traffic communication via a Layer-3 UE-to-UE relay

#### 6.6.2.2 Layer-2 ID update procedure

Figure 6.6.2.2-1 illustrates the procedure of Link Identifier Update.



Figure 6.6.2.2-1 Link identifier update procedure for Non-IP PC5 link with a Layer-3 UE-to-UE relay

1. The source UE decides to change its identifier(s), it sends Link Identifier Update Request with its new Layer2-ID to the UE-to-UE relay as defined in clause 6.4.3.2 of TS 23.304 [3]. The source UE keeps sending data traffic to the UE-to-UE relay with the old identifiers until it sends the Link Identifier Update Ack to the relay.

2. Upon receiving the Link Identifier Update Request message, the UE-to-UE relay assigns a new L2-ID\_R for the link with the source UE and the link with the target UE.

3. UE-to-UE relay sends Link Identifier Update Request to the target UE with the new L2-ID\_R and provides new source UE identifier. The UE-to-UE relay keeps sending data traffic to the target UE with the old identifiers until it sends the Link Identifier Update Ack to the target UE.

4. Target UE sends Link Identifier Update Response with its new Layer2-ID. The target UE continues to receive traffic with the old Layer-2 ID from UE-to-UE relay until the target UE receives traffic with the new Layer-2 ID from the relay. After sending the Link Identifier Update response, the target UE keeps sending data traffic to the relay with the old identifier until it receives the Link Identifier Update Ack message from the relay.

5. UE-to-UE relay sends Link Identifier Update Response to the source UE with the new L2-ID\_R and provides new target UE identifier. The UE-to-UE relay continues to receive traffic with the old L2-ID\_R from the source and target UE until it receives the traffic with new L2-ID\_R from both the source and target UEs. After sending the Link Identifier Update response, the UE-to-UE relay keeps sending data traffic to the source UE with the old identifier until it receives the Link Identifier Update Ack message from the source UE.

6. The source UE sends the Link Identifier Update Ack to the UE-to-UE relay. The source UE continues to receive traffic with the old Layer-2 ID from the relay until the source UE receives traffic with the new Layer-2 ID from the relay.

After step 5 and step 6, the UE-to-UE relay maintains a mapping between the new L2-ID\_R and the new identifiers of the source and target UEs. The UE-to-UE relay keeps the mapping between the old L2-ID\_R and the old identifiers of the source and target UEs until the relay receives the traffic with the new identifiers from both the source and target UEs.

7. The UE-to-UE relay sends Link Identifier Update Ack to the target UE.

8. The source and target UEs start using their new identifiers and the UE-to-UE relay starts to use the new L2-ID\_R. Based on the new mapping information, the UE-to-UE relay transfers the packets accordingly, and the source and target UEs identify the original UE when receiving packets from the UE-to-UE relay.

### 6.6.3 Impacts on Existing Nodes and Functionality

The UE-to-UE relay needs to support the mapping between the L2-ID\_R and the pair of source and target UEs. Regarding QoS handling, the impact to the UE-to-UE relay is the same as solution# 4.

The source and target UEs identify the original UE when receiving packets from the UE-to-UE relay based on the mapping information.

## 6.7 Solution #7: Negotiated UE-to-UE Relay Reselection

### 6.7.1 Description

This solution provides a solution for UE-to-UE Relay reselection in Key Issue #1. Since the solution is independent of how the relay forwards traffic between Source UE and Target UE this solution is applicable to both Layer 2 UE-to-UE Relays and Layer 3 UE-to-UE Relays.

NOTE: The solution was Solution #50 of TR 23.752 [3].

Solution#1 provides a solution for UE-to-UE Relay Selection, and this solution is suitable for initial Relay selection and it could be extended for UE-to-UE Relay reselection. However, it will cause the UE-to-UE Relay in proximity broadcast the relay discovery message. Under some cases, these broadcast messages can be avoided, by Source UE and Target UE negotiating the relay reselection using the existing relay connection.

After the connection between Source UE and Target UE is setup, the Source UE and Target UE may receive relay discovery messages from the other UE-to-UE Relays. The Source UE or Target UE may find that the signal quality with other UE-to-UE Relays is better than that with the currently used UE-to-UE Relay. Alternatively if the Source UE or Target UE finds that the signal quality with the selected UE-to-UE Relay is not good enough, it will initiate the discover message to find the candidate UE-to-UE Relays which can provide a better connection. After new candidate UE-to-UE Relays have been identified, the Source UE or Target UE will initiate the relay reselection procedure and then these two UEs can negotiate UE-to-UE Relay reselection using the existing relay connection.

### 6.7.2 Procedures



Figure 6.7.2-1: UE-to-UE Relay Reselection Procedure

1. Connection between Source UE and Target UE via Relay 1 is setup by using the other solutions such as Solution #9 of TR 23.752 [3] and Solution #2, and Relay 1 is selected as UE-to-UE Relay, such as by using the Solution #1.

2. The Source UE decides to perform UE-to-UE Relay reselection. This may be triggered by receiving the relay discovery message from another UE-to-UE Relay, and the signal quality with this UE-to-UE Relay is better than that with Relay 1. Alternatively the Source UE will initiate the discover message to find candidate UE-to-UE Relays which can provide a better connection, when it finds that the signal quality with Relay 1 is not good enough.

3. After the Source UE identifies the candidate UE-to-UE Relays, the Source UE sends the UE-to-UE Relay reselection request to the Target UE using the connection via Relay 1, and the request message includes the candidate UE-to-UE Relay ID(s) ordered by the Source UE's preference based on e.g. the signal quality of UE-to-UE Relays.

NOTE 1: Details of UE-to-UE Relay reselection request message and how the message is forwarded by UE-to-UE Relay depends on the Layer 2 UE-to-UE Relays and Layer 3 UE-to-UE Relays solution.

4. The Target UE decides to change from Relay 1 to a new UE-to-UE Relay. The new UE-to-UE Relay is chosen from the candidate UE-to-UE Relay ID(s) included in the reselection request. This decision can be based on a new UE-to-UE Relay providing the best signal quality, additionally based on the order of candidate UE-to-UE Relay ID (s) received from the Source UE. If the Target UE has not received a relay discovery message from a candidate UE-to-UE Relay or does not connect to the candidate UE-to-UE Relay, the Target UE may perform the UE-to-UE Relay discovery procedure with a candidate UE-to-UE Relay ID in discovery message.

NOTE 2: Whether and how the signal quality information is used for candidate UE-to-UE Relay selection needs to be coordinated with RAN WG.

5. The Target UE sends a response to the Source UE via Relay 1 that includes the new UE-to-UE Relay ID. If no new UE-to-UE Relay is chosen, the Target UE may not respond to Source UE or send a response indicating Relay reselection failure.

6. [Optional] If the Target UE choses a new UE-to-UE Relay in step 5, the Source UE initiates the connection setup procedure via the new UE-to-UE Relay, and also releases the connection via Relay 1.

#### 6.7.2.1 Layer-2 based UE-to-UE Relay Re-selection

Figure 6.7.2.1-1 illustrates the procedure for UE-to-UE Relay re-selection for Layer-2 based solution (as defined in Sol#9 of TR 23.752 [3]).



Figure 6.7.2.1-1: Layer-2 based UE-to-UE Relay Re-selection

1. A PC5 unicast link is established between Source UE and Target UE via Relay 1 (using Layer-2 based solution as described in sol#9 of TR 23.752 [3]).

2. Traffic is exchanged between the Source UE and the Target UE over the PC5 unicast link, via Relay 1.

3. Source UE detects a condition or receives a trigger to change the UE-to-UE Relay. The Source UE may perform a discovery procedure to obtain a list of candidate UE-to-UE Relay IDs (i.e. RIDs).

4. Source UE sends a Link Modification Request message to Target UE (via Relay 1) including a Relay re-selection indication, a list of candidate RIDs and a source UE link ID, which is used on the Source UE, at steps 9 and/or 10, to associate the existing PC5 unicast link via Relay 1 to the replacing PC5 unicast link with the selected Relay (e.g. Relay 2).

5. Target UE selects a Relay from the received list of candidate RIDs (e.g. Relay 2).

6. Target UE sends a Link Modification Accept message to Source UE (via Relay 1) including the Relay re-selection indication, its Selected RID and a target UE link ID, which is used on the Target UE, at step, 8 to associate the existing PC5 unicast link via Relay 1 to the replacing PC5 unicast link with the selected Relay (i.e. Relay 2).

7. Source UE sends a broadcast Direct Communication Request (DCR) message including the Target UE user info, and the Selected RID and the target UE link ID received from Target UE during the Relay re-selection at step 6.

8. Relay 2 receives the DCR message and verifies if the "Selected RID" value matches its own RID and forwards the DCR message only if the "Selected RID" value matches its own RID. The UE-to-UE Relay adds its RID to the forwarded DCR message (as specified in Layer-2 based sol #9 of TR 23.752 [3]). Target UE receives the DCR message and validates that the target UE link ID matches its link ID as previously sent to Source UE (at step 6). Target UE also verifies that the DCR message is received from its selected RID (i.e. RID2). Target UE uses the target UE link ID to find the previous PC5 unicast link to be replaced by the new PC5 unicast link. The association between the Application Layer identifier and the PC5 unicast link via Relay 1 is updated with the new PC5 unicast link via Relay 2 once the traffic is ready to be switched to the new PC5 unicast link (via Relay 2) (i.e. at step 12).

9. Target UE may trigger the security establishment procedure, via Relay 2, and include the source UE link ID, as received on the Link Modification Request at step 4. The security establishment procedure may be skipped if the existing security context used with the previous PC5 unicast link is re-used with the replacing PC5 unicast link, allowing a quicker link setup and path switching. Source UE uses the source UE link ID to find the previous PC5 unicast link with Relay 1 to be replaced by the new PC5 unicast link being established (i.e. via Relay 2). The association between the Application Layer identifier and the PC5 unicast link via Relay 1 is updated with the new PC5 unicast link via Relay 2 once the traffic is ready to be switched to the new PC5 unicast link (via Relay 2) (i.e. at step 12).

10. Target UE sends a Direct Communication Accept message which may include the source UE link ID from Source UE as received at step (4).

11. A new PC5 unicast link is established between the Source UE and Target UE via the Relay 2.

12. Source UE and Target UE switch the data traffic to the new PC5 unicast link via Relay 2. Source UE or Target UE may terminate the PC5 unicast link via Relay 1.

#### 6.7.2.2 Layer-3 based UE-to-UE Relay Re-selection

Figure 6.7.2.2-1 illustrates the procedure for UE-to-UE Relay re-selection for Layer-3 based solution (as defined in Sol#2).



Figure 6.7.2.2-1: Layer-3 based UE-to-UE Relay Re-selection

1. Source UE has a PC5 unicast link established with Relay 1.

1a. Target UE has a PC5 unicast link established with Relay 1 and exchange IP packets via Relay 1.

2. Source UE has a PC5 unicast link established with Relay 2.

2a. Target UE has a PC5 unicast link established with Relay 2.

3. Source UE and Target UE exchange IP packets via Relay 1.

4. Source UE detects or receives a trigger to change the Relay.

5. Source UE sends a PC5 Link Modification Request message for Target UE (via the PC5 unicast link with Relay 1) which includes a Relay reselection indication, a list of candidate Relay IDs (RIDs), Source UE and Target UE IP addresses used to communicate via Relay 1. The IP addresses are specified since the PC5 Link Modification message does not include these IP addresses which are needed at the Relay to fetch the corresponding PC5 unicast link from its mapping table toward the Target UE (as specified in sol#2).

The list of candidate RIDs is selected based on the PC5 unicast links already established between Source UE and such Relays (RIDs). The IP address of multiple Target UE s may be specified in the case where Source UE is communicating with multiple Target UEs via Relay 1.

6. Relay 1 determines that the message is destined to the Target UE based on the "Relay reselection indication" and Target UE's IP address. Relay 1 sends a PC5 Link Modification Request message to Target UE's IP address (as specified in the message); if multiple Target UEs are impacted, the Relay 1 sends a PC5 Link Modification Request to each of these Target UEs.

7. Based on the relay reselection indication, Target UE knows that the communication with Source UE needs to be handled via another Relay. Target UE selects a RID from the list of candidate RIDs. Target UE may select a RID with which a PC5 unicast link is already established or Target UE may establish a new link with the selected RID.

8. Target UE sends a Link Modification Accept message to Relay 1, which includes a Relay reselection indication, Source UE and Target UE IP addresses used via Relay 1, and Target UE's IP address used via Relay 2 and the selected RID (e.g. RID2).

9. Relay 1, based on the relay reselection indication, sends a PC5 Link Modification Accept message to Source UE using the specified Source UE's IP address.

10. Source UE extracts the selected Relay ID (RID2) from the Link Modification Accept message and sends a Link Modification Ack message which includes its IP address associated to Relay 2.

11. Relay 2 receives this message and forwards it to the Target UE since the Relay reselection indication is specified. This Ack message is needed to synchronise the switch of traffic between the Source UE and Target UE, via the selected UE (Relay 2), at the same time.

12. From this point on, Source UE and Target UE switch the IP traffic to the new PC5 unicast link via Relay 2 (since Source UE and Target UE have exchanged their respective IP address in above steps they can skip performing DNS query steps with Relay 2).

### 6.7.3 Impacts on services, entities and interfaces

**Source UE:**

- Identifies the candidate UE-to-UE Relays, and initiates Relay reselection via the existing connection.

**Target UE:**

- Decides the new UE-to-UE Relay.

**UE-to-UE Relay:**

- Sends/receives discovery messages to/from the Source UE or the Target UE.

## 6.8 Solution #8: Authorization for 5G ProSe UE-to-UE Relay Service

### 6.8.1 Description

This solution addresses KI#1 and #6, and applies to both Layer-2 and Layer-3 UE-to-UE Relay.

NOTE 1: The solution was Solution #36 of TR 23.752 [3].

For KI#1 (Support of UE-to-UE Relay), following aspects are covered:

- Authorize the UE-to-UE Relay, e.g. authorize a UE as UE-to-UE Relay.

- Authorize Source/Target UEs to use a UE-to-UE Relay.

- Provisioning policy and parameters for UE-to-UE Relay service.

For KI#6 (Support of PC5 Service Authorization and Policy/Parameter Provisioning), two following major aspects are covered:

- What are necessary enhancements for the procedures related to PC5 service authorization and policy/parameter provisioning to a UE, compared with what is currently specified in TS 23.304 [3] clause 5.1 and TS 23.502 [8] clause 4.2.2.2 (Registration Procedure), 4.2.4.3 (UE Configuration Update procedure for transparent UE Policy Delivery), 4.16.11 (UE Policy Association Establishment procedure), 4.16.12 (UE Policy Association Modification procedure).

- what are new information for PC5 service authorization and provisioning beyond what is currently specified in TS 23.304 [3] clause 5.1.

The PCF based service authorization and provisioning as defined in TS 23.304 [3] are used as baseline for this solution.

NOTE 2: When the UE-to-UE Relay is out of coverage, it can act as a UE-to-UE Relay based on the preconfigured policy and parameters.

### 6.8.2 Procedures

#### 6.8.2.1 Procedure Enhancement for Information Provisioning to a 5G ProSe Remote UE/UE-to-UE Relay

For PCF based Service Authorization and Provisioning to 5G ProSe Remote UE/UE-to-UE Relay, the Registration procedures as defined in clause 4.2.2.2 of TS 23.502 [8], UE Policy Association Establishment procedure as defined in clause 4.16.11 of TS 23.502 [8] and UE Policy Association Modification procedure as defined in clause 4.16.12 of TS 23.502 [8] apply with the following additions:

- If the UE indicates 5G ProSe capability as a Remote UE/UE-to-UE Relay in the Registration Request message and if the UE is authorized to be a 5G ProSe Remote UE/UE-to-UE Relay based on subscription data, the AMF selects the PCF which supports 5G ProSe information provisioning and establishes a UE policy association with the PCF for 5G ProSe Remote UE/UE-to-UE Relay information provisioning delivery.

- If the AMF receives the 5G ProSe capability as a Remote UE/UE-to-UE Relay in the Registration Request message from UE, the AMF further reports the 5G ProSe capability as a Remote UE/UE-to-UE Relay to the selected PCF. The PCF determines the 5G ProSe Remote UE/UE-to-UE Relay information based on the received 5G ProSe capability as a Remote UE/UE-to-UE Relay.

- If the UE supports 5G ProSe capability as a Remote UE/UE-to-UE Relay and it does not have valid 5G ProSe Remote UE/UE-to-UE Relay information, the UE includes the UE Policy Container with indicating the 5G ProSe UE-to-UE Relay Information Provisioning request during registration procedure.

- If the UE indicates the 5G ProSe Remote UE/UE-to-UE Relay Information Provisioning request in the UE Policy Container, the PCF determines whether to provision the 5G ProSe Remote UE/UE-to-UE Relay Information to the UE, as specified in clause 6.1.2.2.2 of TS 23.503[13], and the PCF provides the 5G ProSe Remote UE/UE-to-UE Relay Information to the UE by using the procedure as defined in clause 4.2.4.3 "UE Configuration Update procedure for transparent UE Policy Delivery" in TS 23.502 [8].

The PCF may update the 5G ProSe Policy and parameters to the UE in following conditions:

- UE Mobility, e.g. UE moves from one PLMN to another PLMN. This is achieved by using the procedure of UE Policy Association Modification initiated by the AMF, as defined in clause 4.16.12.1 of TS 23.502 [8].

- When there is a subscription change in the list of PLMNs where the UE is authorized to perform the 5G operation. This is achieved by using UE Policy Association Modification initiated by the PCF procedure as defined in clause 4.16.12.2 of TS 23.502 [8].

- When there is a change of service specific parameter as described in clause 4.15.6.7 of TS 23.502 [8].

If the serving PLMN is removed from the list of PLMNs in the service authorization parameters, the service authorization is revoked in the UE.

When the UE is roaming, the change of subscription resulting in updates of the service authorization parameters are transferred to the UE by H-PCF via V-PCF.

The UE may perform UE triggered Policy Provisioning procedure to the PCF as specified in clause 6.2.4 of TS 23.304 [3] when the UE determines the 5G ProSe Policy and parameters are invalid (e.g. Policy/Parameter is outdated, missing or invalid).

#### 6.8.2.2 The Policy/parameter to a 5G ProSe UE-to-UE Relay

The following information is provisioned in the UE in support of the UE assuming the role of a 5G ProSe UE-to-UE Relay:

1) Authorisation policy for acting as a 5G ProSe UE-to-UE Relay:

- when the UE is "served by E-UTRA" or "served by NR:

- PLMNs in which the UE is authorized to relay traffic for 5G Remote UE accessing UE-to-UE Relays over PC5 reference point.

- when the UE is "not served by E-UTRA" and "not served by NR:

- Indicates whether the UE is authorized to be a UE-to-UE Relay over PC5 reference point.

2) Radio parameters when the UE is "not served by E-UTRA" and "not served by NR":

- Includes the radio parameters with Geographical Area(s) that need to be configured in the UE in order to be able perform ProSe Direct Discovery and Communication procedures when acting as a 5G ProSe UE-to-UE Relay. These radio parameters (e.g. frequency bands) are defined in TS 38.331 [14] and are common for all types of 5G ProSe Direct Discovery (Group Member Discovery, ProSe UE-to-UE Relay Discovery or ProSe UE-to-UE Relay Discovery Additional Information). The UE uses the radio parameters only if the UE can locate itself in the corresponding Geographical Area. Otherwise, the UE is not authorised to transmit.

3) 5G ProSe Relay Discovery policy/parameters for 5G ProSe UE-to-UE Relay:

- Includes the parameters that enable the UE to perform 5G ProSe Relay Discovery as a UE-to-UE Relay when provisioned from the PCF in the ME or configured in the UICC:

- 5G ProSe UE-to-UE Relay Discovery parameters (User Info ID, Relay Service Code(s)) as described in clause 6.H.2.4;

- Security related content for 5G ProSe Relay Discovery for each 5G ProSe Relay Service Code.

#### 6.8.2.3 The Policy/parameter to a 5G ProSe Remote UE

The following information is provisioned in the UE in support of the UE assuming the role of a 5G ProSe Remote UE accessing a UE-to-UE Relay:

1) Authorisation policy for acting as a 5G ProSe Remote UE:

- when the UE is "served by E-UTRA" or "served by NR:

- PLMNs in which the UE is authorized to access UE-to-UE Relays over PC5 reference point.

- when the UE is "not served by E-UTRA" and "not served by NR:

- Indicates whether the UE is authorized to access a UE-to-UE Relay over PC5 reference point.

2) Radio parameters when the UE is "not served by E-UTRA" and "not served by NR":

- Includes the radio parameters with Geographical Area(s) that need to be configured in the UE in order to be able perform ProSe Direct Discovery and Communication procedures when acting as a 5G ProSe Remote UE accessing a UE-to-UE Relay. These radio parameters (e.g. frequency bands) are defined in TS 38.331 [14] and are common for all types of 5G ProSe Direct Discovery (Group Member Discovery, ProSe UE-to-UE Relay Discovery or ProSe UE-to-UE Relay Discovery Additional Information). The UE uses the radio parameters only if the UE can locate itself in the corresponding Geographical Area. Otherwise, the UE is not authorised to transmit.

3) 5G ProSe Relay Discovery policy/parameters for 5G ProSe Remote UE:

- Includes the parameters that enable the UE to perform 5G ProSe Relay Discovery as a 5G ProSe Remote UE when provisioned from the PCF in the ME or configured in the UICC:

- 5G ProSe UE-to-UE Relay Discovery parameters (User Info ID, Relay Service Code(s)) as described in clause 6.H.2.4;

- Security related content for 5G ProSe Relay Discovery for each 5G ProSe Relay Service Code.

#### 6.8.2.4 5G ProSe UE-to-UE Relay Discovery parameters

5G ProSe UE-to-UE Relay Discovery parameters include:

- User Info ID: For Model A, this corresponds to the Announcer Info parameter when the UE is acting as an announcing UE. For Model B, this corresponds to the Discoverer Info in Solicitation messages and the Discoveree Info in Response messages, when the UE is acting as a discoverer or discoveree UE respectively.

- Relay Service Code(s): A Relay Service Code identifies a connectivity service the ProSe UE-to-UE Relay provides to applications. The Relay Service Codes are configured in the ProSe UE-to-UE Relays that provide connectivity services to applications. The Relay Service Codes are configured in the Remote UEs interested in related connectivity services

### 6.8.3 Impacts on services, entities and interfaces

5G ProSe UE-to-UE Relay:

- Indicates 5G ProSe capability as a UE-to-UE Relay in the Registration Request message;

- Includes the UE Policy Container with indicating the 5G ProSe UE-to-UE Relay Information Provisioning request during registration procedure;

- Receive and enforce the Policy and parameter as 5G ProSe UE-to-UE Relay.

- Act as a 5G ProSe UE-to-UE Relay for direct discovery and communication.

5G ProSe Remote UE:

- Indicates 5G ProSe capability as a Remote UE accessing UE-to-UE Relay in the Registration Request message;

- Includes the UE Policy Container with indicating the 5G ProSe Remote UE accessing a UE-to-UE Relay Information Provisioning request during registration procedure;

- Receive and enforce the Policy and parameter as 5G ProSe Remote UE accessing a UE-to-UE Relay.

- Act as a 5G ProSe Remote UE for direct discovery and communication.

AMF:

- Determine whether UE is authorized to be a 5G ProSe Remote UE/UE-to-UE Relay;

- Select a PCF capable of authorization Policy and parameter for 5G ProSe Remote UE/UE-to-UE Relay;

- Forward UE's PC5 Capability for 5G ProSe Remote UE/UE-to-UE Relay to PCF.

PCF:

- Send the Authorization Policy and parameter to 5G ProSe Remote UE/UE-to-UE Relay.

## 6.9 Solution #9: Model A discovery for 5G ProSe Layer-3 UE-to-UE Relay scenario

### 6.9.1 Description

In this solution, the 5G ProSe UE-to-UE Relay operations follow with the following principles:

- The 5G ProSe UE-to-UE Relay sends out a Relay Announcement message periodically, announcing its availability for serving other UEs in the area.

- A 5G ProSe-enabled UE decides if it can be connected via a 5G ProSe UE-to-UE relay by sending a message to the relay, so that the relay can add the UE into its neighbour list.

- For supporting more than one hop, if required in the future, a hop count per UE in the announcement message could be added if/when multi-hop is added.

- RSC used in the UE-to-UE Relay communication setup procedure is selected during UE-to-UE Relay discovery procedures. The RSC can be associated with one or multiple ProSe identifier(s). The UE-to-UE Relay, the source UE and the target UE are aware of whether an RSC is offering Layer-2 or Layer-3 UE-to-UE Relay service, and whether an RSC is for IP or non-IP based the configured policy.

### 6.9.2 Procedures



Figure 6.9.2-1: 5G ProSe UE-to-UE Relay operation

Figure 6.9.2-1 provides an example operation for the 5G ProSe UE-to-UE Relay

Step 1: Authorization /parameter provisioning for UE-to-UE Relay Service has been performed.

Step 2a: A ProSe 5G UE-to-UE Relay sends out a Relay Announcement message periodically to its proximity, announcing its availability as a UE-to-UE relay. In the Announcement message, it includes its User Info ID, a Relay Service Code (RSC), a list of UEs that are reachable by the relay, we can call it *target UE list*.

Step 2b: When a UE receives a Relay Announcement message, it can decide if it can use the relay according to e.g. Relay Service Code, the User Info ID (e.g. only use some specific UE-to-UE relays). If the relay can serve the UE and the UE wants to be discovered by other UEs via this relay, the UE will send a Response message to the relay. The relay will add the UE ID into its target UE list.

Editor's note: If the response message is a new type of PC5 signaling message is FFS.

When a 5G ProSe UE-to-UE relay receives an Announcement message with target UE list, it may, according to its configuration or policy, add the target the UE list in it own target UE list for each target UE.

Step 3: When the source UE wants to communicate with the target UE via a UE-to-UE relay, the source UE will choose a relay whose target UE list includes the corresponding target UE ID. If there are multiple relays can reach the target UE, then the source UE may select the relay according to relay selection criteria.

Step 4a,4b: The source UE may establish a PC5 link with the selected 5G ProSe UE-to-UE Relay and the 5G ProSe UE-to-UE Relay may establish a PC5 link with the target UE. The details will be addressed in other solutions of KI#1.

The ProSe 5G UE-to-UE Relay stores an association of the User Info of the peer UE of the unicast link and the IP address/prefix of the UE into its DNS entries. The 5G ProSe UE-to-UE Relay acts as a DNS server to other UEs.

Step 5: For IP traffic, the source UE sends a DNS query for the target UE (based on Target User Info to the 5G ProSe UE-to-UE Relay over the unicast link), which will return the IP address/prefix of the target UE .

### 6.9.3 Impacts on services, entities and interfaces

- For IP traffic, the UE-to-UE Relay acts as an IP router and DNS server.

- For non-IP traffic, the UE-to-UE Relay performs traffic relaying based on a mapping between the links with source UE and the links with target UE.

## 6.10 Solution #10: Consolidated Solution for UE-to-UE Relay discovery and selection based on Model A and Model B discovery

### 6.10.1 Description

This solution applies to Key Issue #1 "Support of UE-to-UE Relay". The Model A discovery and Model B discovery procedures proposed in this solution are common procedures applicable for both Layer-2 UE-to-UE Relay and Layer-3 UE-to-UE Relay.

This solution is a consolidated solution for UE-to-UE Relay discovery and selection based on sol#8 alt2(Model B discovery) and sol#11(Model A discovery) of TR 23.752 [2].

RSC is used in the UE-to-UE Relay discovery to indicate the connectivity service the UE-to-UE Relay provides to the source UE. The RSC can be associated with one or multiple ProSe identifier(s). The UE-to-UE Relay, the source UE and the target UE are aware of whether an RSC is offering Layer-2 or Layer-3 UE-to-UE Relay service based configured policy.

NOTE: Source UE, target UE, UE-to-UE Relay decide the RSC used for UE-to-UE Relay discovery based on the Policy/Parameter Provisioning solutions of KI#6 (Support of PC5 Service Authorization and Policy/Parameter Provisioning).

This solution doesn’t assume the discovery procedure is followed by communication procedure, thus the UE-to-UE Relay doesn’t store info for the communication setup in future.

For Model A discovery, the UE-to-UE Relay periodically transmits an Announcement message contains RSC, a list of User Info ID and Layer-2 ID of the potential target UEs. The source UE monitors announcement messages to select the UE-to-UE Relay and get the Layer-2 ID of the target UE.

For Model B discovery, the source UE sends a Discovery Solicitation message contains RSC and optional User Info ID of the target UE, then the UE-to-UE Relay that matches the RSC broadcasts discovery solicitation message. The target UE that matches the RSC and optional the User Info ID of the target UE responds to the UE-to-UE Relay with a Discovery Response message, the UE-to-UE Relay sends a Discovery Response message which contains the User Info ID and Layer-2 ID of the target UE and RSC to the source UE. The source UE selects the UE-to-UE Relay and gets the Layer-2 ID of the target UE.

Editor's note: The privacy and authentication/authorization issues are FFS and need to coordinate with SA WG3.

### 6.10.2 Procedures

#### 6.10.2.1 Model A discovery

Depicted in figure 6.10.2.1-1 is the procedure for UE-to-UE Relay discovery Model A.



Figure 6.10.2.1-1: UE-to-UE Relay discovery with Model A

1. The UE-to-UE Relay decides that it can act as a UE-to-UE Relay based on configured policy, and the UE-to-UE Relay determines a list of User Info ID and Layer-2 ID of the target UEs it can announce based on the previous discovery or based on existing or prior communication between the UE-to-UE Relay and the target UEs. For example, the UE-to-UE Relay may perform the Group Member Discovery procedure (either Model A or Model B) or Direct Discovery procedure (either Model A or Model B) with the RSC it supports to discover target UEs it can announce.

2. The UE-to-UE Relay periodically transmits an Announcement message. The Announcement message contains the Type of Discovery Message, User Info ID of the UE-to-UE Relay, RSC, a list of User Info ID and Layer-2 ID of the target UEs. The Source Layer-2 ID of the Announcement message is self-assigned by the UE-to-UE Relay, the Destination Layer-2 ID is selected based on the configured policy.

Editor's note: How to announce the target UE list considering size limitation of the Announcement message is FFS.

Editor's note: How the UE-to-UE Relay gets the up-to-date target UE list is FFS.

Editor’s note: Whether the Announcement message can be used in the discovery in step 1 is FFS.

3. The source UE monitors announcement messages with the RSC and the User Info ID of the target UE. The source UE selects the UE-to-UE Relay and gets the Layer-2 ID of the target UE based on the information received in step 1.

#### 6.10.2.2 Model B discovery

Depicted in figure 6.10.2.2-1 is the procedure for UE-to-UE Relay discovery Model B.



Figure 6.10.2.2-1: UE-to-UE Relay discovery with Model B

1. The source UE sends a Discovery Solicitation message contains the Type of Discovery Message, User Info ID of the source UE, RSC and optional User Info ID of the target UE and a relay indication. The Source Layer-2 ID is self-assigned by the source UE, the Destination Layer-2 ID is selected based on the configured policy. The relay indication indicates how many hops that the source UE wants the discovery message to be forwarded away.

NOTE: In release 18, the value of relay indication is set to one and may not be needed.

2. On reception of discovery solicitation message, the UE-to-UE Relay that matches the RSC broadcasts discovery solicitation message contains the Type of Discovery Message, User Info ID of the source UE, User Info ID of the UE-to-UE Relay, RSC, and optional User Info ID of the target UE. The Source Layer-2 ID is self-assigned by the UE-to-UE Relay, the Destination Layer-2 ID is selected based on the configured policy. If the relay indication is 0, then the relay UE will not broadcast the discovery message, otherwise, it will decrease the relay indication by 1 and update it in the discovery message.

3. The target UE that matches the RSC which is associated to its desired connectivity service and optional the User Info ID of the target UE responds to the UE-to-UE Relay with a Discovery Response message. The Discovery Response message contains the Type of Discovery Message, User Info ID of the target UE, User Info ID of the UE-to-UE Relay, User Info ID of the source UE, and RSC. The Source Layer-2 ID is self-assigned by the target UE, the Destination Layer-2 ID is the Source Layer-2 ID of the received Discovery Solicitation message from UE-to-UE Relay. If the target UE receives multiple discovery solicitation messages from different UE-to-UE Relays, i.e. UE-to-UE Relay-1 and UE-to-UE Relay-2 in the figure, it responds to each UE-to-UE Relay separately.

4. The UE-to-UE Relay sends a Discovery Response message contains the Type of Discovery Message, User Info ID and Layer-2 ID of the target UE, User Info ID of the UE-to-UE Relay, User Info ID of the source UE, and RSC. The Source Layer-2 ID is self-assigned by the UE-to-UE Relay, the Destination Layer-2 ID is the Source Layer-2 ID of the received Discovery Solicitation message from source UE. The Layer-2 ID of the target UE in the Discovery Response message is the Source Layer-2 ID of the received message from target UE in step3.

5. The source UE performs the UE-to-UE Relay selection.

### 6.10.3 Impacts on services, entities and interfaces

**UE:**

- New functionality related to UE-to-UE Relay discovery and selection.

## 6.11 Solution #11: Consolidated Solution for Layer-3 UE-to-UE Relay communication setup after Model A and Model B discovery

### 6.11.1 Description

This solution applies to Key Issue #1 "Support for UE-to-UE Relay" to support communication setup for Layer-3 UE-to-UE Relay. It can be taken as a merged and consolidated solution of sol#32, Sol#49 and Sol#31 of TR 23.752 [2]. The assumption is that source UE has selected a suitable UE-to-UE Relay and received the Layer-2 ID of the target UE after Model A or Model B discovery.

RSC used in the UE-to-UE Relay communication setup procedure is selected during UE-to-UE Relay discovery procedures. The RSC can be associated with one or multiple ProSe identifier(s). The UE-to-UE Relay, the source UE and the target UE are aware of whether an RSC is offering Layer-2 or Layer-3 UE-to-UE Relay service, and whether an RSC is for IP or non-IP based the configured policy.

This solution is applicable for both IP and non-IP traffic. For non-IP traffic, the UE-to-UE Relay stores the 1:1 mapping between the link with source UE and the link with target UE, thus Direct Communication Request is always provided by source UE to the UE-to-UE Relay and provided by the UE-to-UE Relay to target UE. For IP traffic, the UE-to-UE Relay acts as an IP router, the link between source UE and UE-to-UE Relay can be shared by multiple target UEs, the link between UE-to-UE Relay and target UE can be shared by multiple source UEs. If there’s no PC5 link between source UE and the UE-to-UE Relay existing for the required RSC, or for non-IP traffic transmitting, Source UE sends the Direct Communication Request to the UE-to-UE Relay which contains User Info ID of UE-to-UE Relay, User Info ID and Layer-2 ID of target UE, RSC. If there’s an existing PC5 link between source UE and the UE-to-UE Relay for the required RSC which is related to IP type traffic, source UE sends a Link Modification Request to the UE-to-UE Relay contains User Info ID and Layer-2 ID of target UE. If there’s no PC5 link between the UE-to-UE Relay and the target UE existing for the required RSC, or for non-IP traffic transmitting, the UE-to-UE Relay sends Direct Communication Request to the target UE using the received Layer-2 ID of target UE as the Destination Layer-2 ID. If there’s an existing PC5 link between the UE-to-UE Relay and the target UE for the required RSC which is related to IP type traffic, the UE-to-UE Relay sends a Link Modification Request to the target UE. After receiving the response from target UE, for IP traffic, UE-to-UE Relay provides the IP address of target UE to source UE.

### 6.11.2 Procedures

Depicted in figure 6.11.2-1 is the procedure for Layer-3 UE-to-UE Relay communication setup.



Figure 6.11.2-1: Layer-3 UE-to-UE Relay communication setup after Model A and Model B discovery

0. Source UE has selected a suitable UE-to-UE Relay and received the Layer-2 ID of the target UE after Model A or Model B discovery. Source UE decides to connect with target UE via the selected UE-to-UE Relay.

1a. If there’s no PC5 link between source UE and the UE-to-UE Relay existing for the required RSC, or for non-IP traffic transmitting, Source UE sends a Direct Communication Request to the UE-to-UE Relay. The Direct Communication Request contains User Info ID of source UE, User Info ID of UE-to-UE Relay, User Info ID and Layer-2 ID of target UE, RSC. The Source Layer-2 ID of the Direct Communication Request is self-assigned by the source UE, the Destination Layer-2 ID of the Direct Communication Request is the source Layer-2 ID of the selected UE-to-UE Relay during UE-to-UE Relay discovery.

1b. If there’s an existing PC5 link between source UE and the UE-to-UE Relay for the required RSC which is related to IP type traffic, source UE sends a Link Modification Request to the UE-to-UE Relay. The Link Modification Request contains User Info ID and Layer-2 ID of target UE, end-to-end QoS to the target UE.

2. After step1a, if the UE-to-UE Relay matches the User Info ID of UE-to-UE Relay and RSC, it responds by establishing the security with source UE. When the security protection is enabled, source UE sends the information as described in clause 6.4.3.1 of TS 23.304 including end-to-end QoS to the target UE.

3. The UE-to-UE Relay splits the end-to-end QoS into two parts: one part is for the PC5 interface between source UE and UE-to-UE Relay, the other part is for the PC5 interface between UE-to-UE Relay and the target UE.

Editor's note: How UE-to-UE Relay splits the end-to-end QoS is FFS.

4a. If there’s no PC5 link between the UE-to-UE Relay and the target UE exist for the required RSC, or for non-IP traffic transmitting, the UE-to-UE Relay sends a Direct Communication Request to the target UE. The Direct Communication Request contains User Info ID of source UE, User Info ID of UE-to-UE Relay, User Info ID of target UE, RSC. The Source Layer-2 ID of the Direct Communication Request is self-assigned by the UE-to-UE Relay, the Destination Layer-2 ID of the Direct Communication Request is the Layer-2 ID of target UE received in step1.

NOTE: For non-IP traffic, the UE-to-UE Relay use different Source Layer-2 IDs in the Direct Communication Requests towards the same target UE for different source UEs.

4b. If there’s an existing PC5 link between the UE-to-UE Relay and the target UE for the required RSC which is related to IP type traffic, the UE-to-UE Relay sends a Link Modification Request to the target UE. The Link Modification Request contains User Info ID of source UE, QoS part between UE-to-UE Relay and the target UE.

5. After step4a, if the target UE matches the User Info ID of target UE and RSC, it responds by establishing the security with UE-to-UE Relay. When the security protection is enabled, UE-to-UE Relay sends the information to target UE, the information is as described in clause 6.4.3.1 of TS 23.304 including QoS part between UE-to-UE Relay and the target UE.

6a. After step5, the target UE sends the Direct Communication Accept as described in clause 6.4.3.1 of TS 23.304 to the UE-to-UE Relay.

6b. After step4b, the target UE sends the Link Modification Accept as described in clause 6.4.3.4 of TS 23.304 to the UE-to-UE Relay.

7. For IP traffic, IPv6 prefix or IPv4 address is allocated for the target UE.

8a. if step1a is performed, the UE-to-UE Relay sends the Direct Communication Accept as described in clause 6.4.3.1 of TS 23.304 to the source UE. For IP traffic, the Direct Communication Accept in addition contains the IP address of target UE. For non-IP traffic, the UE-to-UE Relay stores the 1:1 mapping between the link with source UE and the link with target UE.

8b. if step1b is performed, the UE-to-UE Relay sends the Link Modification Accept as described in clause 6.4.3.4 of TS 23.304 to the source UE. the Link Modification Accept in addition contains the IP address of target UE.

9. For IP traffic, IPv6 prefix or IPv4 address is allocated for the source UE.

Editor's note: It is FFS whether the IPv6 prefix or IPv4 address is allocated by the UE-to-UE Relay for the source UE and target UE, and how the source UE and target UE get the IP addresses of each other.

The UE-to-UE Relay performs relaying function at the corresponding layer as follows:

- For IP traffic, the UE-to-UE Relay acts as an IP router.

- For non-IP traffic, the UE-to-UE Relay performs traffic relaying based on a mapping between the link with source UE and the link with target UE.

### 6.11.3 Impacts on services, entities and interfaces

**UE:**

- New functionality related to UE-to-UE Relay communication setup.

## 6.12 Solution #12: Layer-3 UE-to-UE Relay discovery and communication

### 6.12.1 Description

The solution applies to Key Issue #1 "Support of UE-to-UE Relay".

In this solution, the Layer-3 UE-to-UE Relay operation is supported with the following principles:

- Authorization and configuration:

- Only the UE authorized by the service authorization configuration can act as a UE-to-UE Relay. These UEs will be configured according to the service authorization and provisioning solutions for Key Issue #6.

- UE-to-UE Relay discovery:

- Model A and Model B direct discovery as defined in clause 6.3.2 of TS 23.304 [3] are supported for UE-to-UE Relay discovery.

- Relay Service Code (RSC) is used to indicate the connectivity service that UE-to-UE Relay can support.

- In order to serve as a UE-to-UE Relay, it is required to discover other UEs in proximity in advance or on demand.

- The Source and Destination Layer-2 IDs used for discovery message are determined based on the principles as defined in clause 5.8 of TS 23.304 [3].

- UE-to-UE Relay communication:

- Source UE initiates the Layer-2 link establishment procedure as defined in clause 6.4.3.1 of TS 23.304 [3] with UE-to-UE Relay, and the QoS Info and IP address are negotiated during this procedure.

- The UE-to-UE Relay initiates the Layer-2 link establishment procedure as defined in clause 6.4.3.1 of TS 23.304 [3] with Target UE, and the QoS Info and IP address are negotiated during this procedure.

- IP, Ethernet and Unstructured traffic type are supported.

- Both UE-to-UE Relay allocated IP address and Link-Local IPv6 address are supported.

- QoS handling:

- When the Source UE establishes the unicast Layer-2 link with the UE-to-UE Relay, it can establish corresponding PC5 QoS Flows according to procedure defined in clause 6.4.3.1 of TS 23.304 [3]. The UE-to-UE Relay determines the PC5 QoS parameters used on the PC5 QoS Flow between Source UE and UE-to-UE Relay, as well as the PC5 QoS parameters used on the PC5 QoS Flow between UE-to-UE Relay and Target UE.

- The PC5 QoS Flows are also set up between UE-to-UE Relay and Target UE using the PC5 QoS parameters determined by UE-to-UE Relay.

The Control Plane and User Plane protocol stacks of Layer-3 UE-to-UE Relay are as followings.



Figure 6.12.1-1: Control plane for Layer-3 UE-to-UE Relay



Figure 6.12.1-2: User plane for Layer-3 UE-to-UE Relay

### 6.12.2 Procedures

#### 6.12.2.1 Procedures for UE-to-UE Relay discovery

##### 6.12.2.1.1 Procedure for UE-to-UE Relay discovery with Model A

Depicted in figure 6.12.2.1.1-1 is the procedure for UE-to-UE Relay discovery with Model A.



Figure 6.12.2.1.1-1: UE-to-UE Relay discovery with Model A

1. The UE-to-UE Relay has discovered other UEs in proximity via the previous direct discovery or direct communication procedures. The UE-to-UE Relay obtains the User Info ID, Relay Service Code (RSC) and Layer-2 ID of other UEs in proximity. The UE-to-UE Relay stores these parameters for subsequent UE-to-UE Relay communication as described in clause 6.12.2.2. These parameters can be removed by UE-to-UE Relay in case UE-to-UE Relay communication is established.

Editor's note: Other triggers for removal of these parameters are FFS.

2. The UE-to-UE Relay sends an Announcement message. The Announcement message may include the Type of Discovery Message, User Info ID of the UE-to-UE Relay, RSC, and a list of User Info ID of the Target UEs (UEs discovered in step 1).

The Source Layer-2 ID of the Announcement message is self-assigned by the UE-to-UE Relay, and the Destination Layer-2 ID is selected based on the ProSe policy.

##### 6.12.2.1.2 Procedure for UE-to-UE Relay discovery with Model B

Depicted in figure 6.12.2.1.2-1 is the procedure for UE-to-UE Relay discovery with Model B.



Figure 6.12.2.1.2-1: UE-to-UE Relay discovery with Model B

1. The UE-to-UE Relay may have discovered other UEs in proximity via the previous direct discovery or direct communication procedures. The UE-to-UE Relay obtains the User Info ID, Relay Service Code (RSC) and Layer-2 ID of other UEs in proximity.

2. The Source UE sends a Solicitation message. The Solicitation message may include the Type of Discovery Message, User Info ID of Source UE, RSC, and User Info ID of Target UE.

The Source Layer-2 ID of the Announcement message is self-assigned by the Source UE, and the Destination Layer-2 ID is selected based on the ProSe policy.

3. The UE-to-UE Relay may perform direct discovery procedure to discover the Target UE if it has not been discovered in step 1. The UE-to-UE Relay obtains the User Info ID, Relay Service Code (RSC) and Layer-2 ID of Target UEs in proximity. The UE-to-UE Relay stores these parameters for subsequent UE-to-UE Relay communication as described in clause 6.12.2.2. These parameters can be removed by UE-to-UE Relay in case UE-to-UE Relay communication is established.

4. The UE-to-UE Relay that match the values of the User Info ID of Target UE and RSC contained in the Solicitation message respond to the Source UE with a Response message. The Response message contains the Type of Discovery Message, User Info ID of UE-to-UE Relay, RSC, and User Info ID of Target UE.

The Source Layer-2 ID of the Response message is self-assigned by the UE-to-UE Relay, and the Destination Layer-2 ID is set to the Source Layer-2 ID of the received Solicitation message.

#### 6.12.2.2 Procedures for UE-to-UE Relay communication

Depicted in figure 6.12.2.2-1 is the procedure for Layer-3 UE-to-UE Relay communication.



Figure 6.12.2.2-1: Layer-3 UE-to-UE Relay communication

1. Service authorization and provisioning are performed for Source UE, Target UE and UE-to-UE Relay as described for solutions for Key Issue #6.

2. The Source UE performs discovery of a UE-to-UE Relay as described in clause 6.12.2.1.

3. The Source UE sends a Direct Communication Request message to initiate the unicast Layer-2 link establishment procedure with the UE-to-UE Relay. The Direct Communication Request message includes User Info ID of Source UE, User Info ID of UE-to-UE Relay, User Info ID of Target UE and Relay Service Code (RSC).

The Source Layer-2 ID of the DCR message is self-assigned by the Source UE, and the Destination Layer-2 ID is set to the Source Layer-2 ID of the discovery message of UE-to-UE Relay.

4. If the User Info ID of Target UE, User Info ID of UE-to-UE Relay and RSC are included in the Direct Communication Request, the UE-to-UE Relay responds by establishing the security with Source UE. When the security protection is enabled, the Source UE sends IP Address Configuration or Link-Local IPv6 address (if IP communication is used), QoS Info (PFI and PC5 QoS parameters).

The Source Layer-2 ID used for the security establishment procedure is self-assigned by the UE-to-UE Relay, and the Destination Layer-2 ID is set to the Source Layer-2 ID of the received Direct Communication Request message.

Upon receiving the security establishment procedure messages, the Source UE obtains the UE-to-UE Relay's Layer-2 ID for future communication, for signaling and data traffic for this unicast link.

5. The UE-to-UE Relay sends a Direct Communication Accept message to the Source UE that has successfully established security with UE-to-UE Relay. The Direct Communication Accept message includes User Info ID of Source UE, User Info ID of UE-to-UE Relay, User Info ID of Target UE, QoS Info (PFI and split PC5 QoS parameters), RSC, IP Address Configuration or Link-Local IPv6 address (if IP communication is used).

6. Triggered by step 3, the UE-to-UE Relay sends a Direct Communication Request message to initiate the unicast Layer-2 link establishment procedure with the Target UE. The Direct Communication Request message includes User Info ID of Source UE, User Info ID of UE-to-UE Relay, User Info ID of Target UE and Relay Service Code (RSC).

The Source Layer-2 ID of the DCR message is self-assigned by the UE-to-UE Relay, and the Destination Layer-2 ID is set to the Source Layer-2 ID of the discovery message of Target UE.

7. If the User Info ID of Target UE and RSC are included in the Direct Communication Request, the Target UE responds by establishing the security with UE-to-UE Relay. When the security protection is enabled, the UE-to-UE Relay sends IP Address Configuration or Link-Local IPv6 address (if IP communication is used), QoS Info (PFI and split PC5 QoS parameters).

The Source Layer-2 ID used for the security establishment procedure is self-assigned by the Target UE, and the Destination Layer-2 ID is set to the Source Layer-2 ID of the received Direct Communication Request message.

Upon receiving the security establishment procedure messages, the UE-to-UE Relay obtains the Target UE's Layer-2 ID for future communication, for signaling and data traffic for this unicast link.

8. The Target UE sends a Direct Communication Accept message to the UE-to-UE Relay that has successfully established security with Target UE. The Direct Communication Accept message includes User Info ID of Source UE, User Info ID of UE-to-UE Relay, User Info ID of Target UE, QoS Info (PFI and split PC5 QoS parameters), RSC, IP Address Configuration or Link-Local IPv6 address (if IP communication is used).

The UE-to-UE Relay may further update the PC5 link with the Source UE based on the outcome of PC5 link establishment with the Target UE.

9. For IP communication, the UE-to-UE Relay stores an association of User Info ID and the IP address of Target UE into its DNS entries, and the UE-to-UE Relay acts as a DNS server to other UEs. The Source UE sends a DNS query to the UE-to-UE Relay to request IP address of Target UE after step 8, and the UE-to-UE Relay returns the IP address of the Target UE to the Source UE.

NOTE: The Source UE may send DNS query multiple times to obtain the IP address of Target UE.

10. The Source UE communicates with the Target UE via the UE-to-UE Relay. For IP communication, the UE-to-UE Relay acts as an IP router. For Unstructured communication, the UE-to-UE Relay performs traffic relaying based on the mapping between the two PC5 Layer-2 links and PC5 QoS Flows. For Ethernet communication, the UE-to-UE Relay acts as an Ethernet switch.

In case of one Source UE communicates with multiple Target UEs, the PC5 link between Source UE and UE-to-UE Relay can be shared for multiple Target UEs while the PC5 link is established individually between UE-to-UE Relay and Target UEs. For the shared PC5 link, the Layer-2 link modification procedure can be used.

In case of multiple Source UEs communicate with one Target UE, the PC5 link is established individually between Source UEs and UE-to-UE Relay while the PC5 link between UE-to-UE Relay and Target UE can be shared. For the shared PC5 link, the Layer-2 link modification procedure can be used.

### 6.12.3 Impacts on services, entities and interfaces

UE:

- New functionality related to UE-to-UE Relay discovery, as well as communication via UE-to-UE Relay.

## 6.13 Solution #13: Layer-2 UE-to-UE Relay

### 6.13.1 Description

#### 6.13.1.1 General

Using the solution described in this clause, a UE-to-UE Relay is authorized to relay messages between two UEs over the PC5 interface via authorization and provisioning.

A UE-to-UE Relay enables a source UE and a target UE to establish an end-to-end (E2E) PC5 unicast communication.

The UE-to-UE Relay listens for Direct Communication Request messages from surrounding UEs and, if the specified application matches one of the applications from its provisioned relay policy/parameters, the UE-to-UE Relay advertises it as a relayed application by adding a relay indication (e.g. Relay ID) to the message.

The target UE receives a broadcast Direct Communication Request message with a relay indication.

A secure "extended" (end-to-end) PC5 link is set up between the source UE and the target UE via the UE-to-UE Relay. Source/Target UEs send and receive messages through the UE-to-UE Relay, however, the security association and the extended PC5 unicast link are established end-to-end between the source UE and the target UE. The UE-to-UE Relay forwards the messages transparently, without the ability to read, modify their content or replay them, with the exception of the Direct Communication Request message. As DCR is always sent unprotected the UE-to-UE Relay modifies the message to include the relay indication (e.g. Relay ID). The source/target UEs detect that the link establishment is going through a UE-to-UE Relay upon detecting a relay indication included in the received messages.

A source/target UE uses a unique link (i.e. PC5 unicast link) with a UE-to-UE Relay to send messages to its peer UEs via this specific UE-to-UE Relay. The UE-to-UE Relay receives E2E PC5 messages over this PC5 unicast link and forwards them between the source UE and target UEs using an adaptation layer, which contains information identifying the specific source and/or target UE. The UE-to-UE Relay replaces the identifiers specified in the messages’ headers with relay-specific identifiers to “isolate” the PC5 unicast links, i.e. different identifiers are used over each PC5 unicast link.

NOTE 1: Additional security-related parameters and procedures may be needed for the protection of relayed messages using the adaptation layer. Their definitions need to be coordinated with SA WG3.

To enable a single step for direct and indirect link establishment procedure, a source UE (i.e. UE1) sends a DCR message without an adaptation header. A target UE (i.e. UE2) may receive the DCR message directly from the source UE and establish a direct unicast link with the source UE. As well, a UE-to-UE Relay may receive the DCR message and add an adaptation header before forwarding it. Another target UE (i.e. UE3) may receive the DCR message via the UE-to-UE Relay and establish an indirect unicast link with the source UE.

NOTE 2: The details about the identity information of source UE and/or target UE specified in the adaption header will be defined in cooperation with RAN WG2 during normative phase.

Link management (i.e. keep-alive, link modification, link identifier update and link release) is supported over extended PC5 links. Since the security association of extended PC5 links is between the E2E peer UEs, all messages sent over the extended PC5 link, including link management (i.e. PC5-S) messages, may only be processed by those two UEs. No modifications to the keep-alive, link modification and link release procedures are needed when sent over the E2E PC5 link. Modifications for the support of the Link Identifier Update procedure related to extended PC5 links are expected and are specified in another contribution.

The PC5 unicast link, used by source/target UEs to send E2E messages via a specific UE-to-UE Relay, is also used as a management link, i.e. to manage the extended links (e.g. for QoS adaptation or privacy procedure). The management link is secured between the source/target UEs and the UE-to-UE Relay and doesn’t make use of an adaptation layer.

#### 6.13.1.2 Control and User Plane Protocol Stacks

The control and user plane protocols stacks are based on the architectural reference model described in Annex A.

### 6.13.2 Procedures

Connection establishment via a L2 UE-to-UE Relay is done after the discovery procedure (i.e. using Discovery messages as defined in 23.304 [3] clause 6.3) i.e. Models A/B or using the integrated discovery procedure (i.e. using the link establishment procedure as defined in clause 6.4.3.1 of TS 23.304 [3]).

If the discovery procedure is run prior to the link establishment, the source UE determines the UE-to-UE Relay Layer-2 ID to be used to reach the target UE while the target UE Layer-2 ID may be discovered and kept at the UE-to-UE Relay or at the source UE or may not be kept. In the latter case, a broadcast Layer-2 is used when sending the DCR message towards the target UE. In this case, the Target User Info field is used to identify the target UE.

If the integrated discovery mechanism is used, the source UE sends the DCR message to a broadcast Layer-2 ID and the UE-to-UE relay forwards the message using the same value.

Figure 6.13.2-1 shows the unicast link establishment over PC5 reference point via a Layer-2 UE-to-UE Relay.



Figure 6.13.2-1: Connection establishment procedure via Layer-2 UE-to-UE Relay

0. UE-to-UE Relay registers with the network and specifies its relay capabilities. UE-to-UE Relay is provisioned with relay policy parameters from the network.

1. The target UEs (i.e. UE2, UE3 and UE4) determine the destination Layer-2 ID (i.e. broadcast Layer-2 ID) for signalling reception for PC5 unicast link establishment as specified in clause 6.4.3.1 of TS 23.304 [3].

2. On the source UE (i.e. UE1), the application layer provides application information to the ProSe layer for PC5 unicast communication. The application information includes the ProSe Service Info, source UE's Application Layer ID, and may include target UE's Application Layer ID, as specified in TS 23.304 [3] clause 6.4.3.1.

ProSe layer triggers the link establishment procedure by sending a Direct Communication Request (DCR) message which includes:

- Source User Info: the initiating UE's Application Layer ID (i.e. UE1's Application Layer ID).

- If the ProSe application layer provided the target UE's Application Layer ID in step 2, the following information is included:

- Target User Info: the target UE's Application Layer ID (i.e. UE2's Application Layer ID).

- ProSe Service Info: the information about the ProSe identifier(s) requesting Layer-2 link establishment.

- Security Information: the information for the establishment of security.

The message is sent using the source Layer-2 ID self-assigned by the source UE and the broadcast Layer-2 ID or the discovered UE-to-UE Relay Layer-2 ID as destination, and includes other parameters related to the application offered, as specified in TS 23.304 [3] clause 6.4.3.1. The message may include the target UE Layer-2 ID, if learned during a prior discovery procedure.

The DCR message is sent without an adaptation layer header. This DCR message may be used for direct and/or indirect link establishment. A target UE receiving the DCR directly from UE1 may continue the link establishment procedure as usual.

3. The UE-to-UE Relay receives the Direct Communication Request message and verifies if it's configured to relay this application, i.e. it compares the announce ProSe Service Info with its provisioned relay policy/parameters.

The UE-to-UE Relay forwards the Direct Communication Request message by using its own Layer-2 ID as Source L2 ID and specifies as destination either the target UE Layer-2 ID as specified in the received DCR message or as learned during the prior discovery procedure, or uses the broadcast Layer-2 ID. The UE-to-UE Relay adds an adaptation header containing info identifying UE1. The UE-to-UE Relay additionally includes its unique Relay ID and relay-specific security info. The UE-to-UE Relay keeps the association of UE1 security info as specified in the DCR message and its relay-specific security info as specified with the forwarded DCR message.

NOTE: The UE-to-UE Relay handles DCR message in the ProSe layer. Any subsequent E2E messages (i.e. PC5-S and data) are forwarded based on UE identifier info specified in the adaptation header.

4. Target UE (i.e. UE3) receives the DCR message via the UE-to-UE Relay. UE3 is interested in the announced application thus it triggers a PC5 unicast link establishment with the UE-to-UE Relay, if such a link isn’t already established between UE3 and this UE-to-UE Relay.

UE3 may receive multiple DCR messages via different UE-to-UE Relays and even directly from UE1. UE3 may select the UE-to-UE Relay based on locally configured rules. UE3 establishes a PC5 unicast link only with the selected UE-to-UE Relay.

5. UE3 continues E2E link establishment procedure by initiating the security procedures (i.e. PC5 Authentication and/or PC5 Direct Security Mode procedures) via the selected UE-to-UE Relay (i.e. over the direct PC5 link to the UE-to-UE Relay). UE3 adds an adaptation header including the info identifying UE1, as received with the DCR message, and UE3 security info and may include a UE3 identifier. UE3 associates the security info received on the DCR message and its UE3 security info to create the security context for the extended link. UE3 includes the Relay ID in the first protected message sent to UE1.

The UE-to-UE Relay forwards the messages from UE3 to UE1 including relay-specific info identifying UE3 in the adaptation header. The UE-to-UE Relay also specifies a relay-specific security info associated to UE3 and UE1 security info as received with the DCR message, and finally may include info identifying UE1 and associated with the DCR message (e.g. UE1 Layer-2 ID used by UE1 when sending the DCR message). UE-to-UE Relay puts its Layer-2 ID as the source and UE1 Layer-2 ID as the destination. The UE-to-UE Relay keeps the association of UE3 security info as specified in message received from UE3 and its relay-specific security info associated to UE3.

6. At the reception of this first message from UE3 via the UE-to-UE Relay, , UE1 extracts the Relay ID and verifies if a PC5 unicast link is already established between UE1 and this UE-to-UE Relay. If none already exists, UE1 triggers a PC5 unicast link establishment procedure before proceeding security procedures of step 5 . UE1 keeps track of the security info specified with the received message (i.e. security info associated to UE3), and uses it to create the security context for the extended link.

7. Once E2E link security establishment procedures are completed, UE3 completes the E2E link establishment procedure via the UE-to-UE Relay by sending a DCA message to UE1.

8. UE1 receives the DCA message. An "extended" unicast link is established between UE1 and UE3, via the UE-to-UE Relay. The extended link may be secured end-to-end, i.e. a security association is created between UE1 and UE3.

9. UE1 and UE3 exchange E2E data via the UE-to-UE Relay, using an adaptation header. The UE-to-UE Relay replaces the fields specified in the adaptation header with relay-specific identifiers, as specified above before forwarding the E2E messages.

Editor's note: The need and details of the E2E authentication and E2E security procedure will be investigated by SA WG3.

Editor's note: The details of the adaptation between two PC5 interfaces are confirmed by RAN WG2.

### 6.13.3 Impacts on services, entities and interfaces

The solution has impacts in the following entities:

UE/ Layer-2 UE-to-UE:

- Needs to support procedures for ProSe 5G Layer-2 UE-to-UE Relay and communications via a ProSe 5G Layer-2 UE-to-UE Relay.

- Needs to support procedures for extended communication management, via communication with a ProSe 5G Layer-2 UE-to-UE Relay.

- Needs to support an adaptation layer for communication via a Layer-2 UE-to-UE Relay.

## 6.14 Solution #14: Criteria for two indirect network path switches

### 6.14.1 Description

This solution is related to the Key Issue #2: Support of path switching between two indirect network communication paths for UE-to-Network Relaying with service continuity consideration, and it mainly focus on the following sub-KIs:

- What the triggers and criteria for path switching.

- How to select a UE-to-Network Relay for path switching.

As described in clause 6.5.3 of TS 23.304 [3], after being connected to the 5G ProSe UE-to-Network Relay, the 5G ProSe Remote UE keeps performing the measurement of the signal strength of PC5 unicast link with the 5G ProSe UE-to-Network Relay for relay reselection. When the measured signal strength is lower than a threshold, the 5G Prose Remote UE will perform the 5G ProSe UE-to-Network relay reselection for indirect network path switching. Currently the descriptions in clause 6.5.4 of TS 23.304 [3] for 5G ProSe Remote UE traffic handling are more suitable to initial UE-to-Network relay selection, it is not clear enough for a target indirect network path re-selection when to perform the indirect network path switching. For example, when a L3 remote UE(without N3IWF case) needs to perform path switching, then what the target indirect path should be selected, does it still selects the L3 relay without N3IWF, L3 relay with N3IWF, or L2 relay? Does it keeps evaluating the next RSD or re-evaluate the URSP?, etc. These issues are still not clear for studying. In this solution, taking the backward compatibility into consideration, the Remote UE still use the URSP evaluation to determine the UE-to-Network relay reselection as specified in clause 6.14.2, 6.14.3 and 6.14.4.

Editor's note: The criteria on path switching from RAN perspective are FFS.

NOTE: This solution studies the criteria on how to select a UE-to-Network Relay for path switching.

### 6.14.2 Criteria for path switching for 5G ProSe Layer-3 relay without N3IWF

5G ProSe Layer-3 Remote UE that is connected to the 5G ProSe Layer-3 UE-to-Network Relay without N3IWF for traffic transmission means the selected RSD has the component of "5G ProSe Layer-3 UE-to-Network Relay Offload indication". When it determines the indirect network path switching for another path selection, it follows the following steps:

* The 5G ProSe Layer-3 Remote UE shall still first perform the 5G ProSe Layer-3 UE-to-Network Relay UE discovery and selection with the "5G ProSe Layer-3 UE-to-Network Relay Offload indication", if there is a 5G ProSe Layer-3 UE-to-Network Relay UE can be discovered and selected, the target indirect network path to be switched is 5G ProSe Layer-3 UE-to-Network Relay path. If not, the 5G ProSe Layer-3 Remote UE may re-evaluate the URSP and the RSD within it according to the precedence. During this process, if the same relay type is appeared again, the Remote UE evaluates the next RSD.

- After that, if the next selected RSD has the preferred non-3GPP access type and the ProSe policy has the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF configurations, the target indirect path to be switched is 5G ProSe Layer-3 UE-to-Network Relay with N3IWF path. Then the 5G ProSe Layer-3 Remote UE performs the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF discovery and selection. If the next selected RSD has the preferred 3GPP access type and the ProSe policy has the 5G ProSe Layer-2 UE-to-Network Relay configurations, the target indirect network path to be switched is 5G ProSe Layer-2 UE-to-Network Relay path. Then the 5G ProSe Remote UE performs the 5G ProSe Layer-2 UE-to-Network Relay discovery and selection. If there are multiple 5G ProSe UE-to-Network Relay UEs can be selected, it depends on Remote UE’s implementation to perform the 5G ProSe UE-to-Network Relay UE selection.

### 6.14.3 Criteria for path switching for 5G ProSe Layer-3 relay with N3IWF

5G ProSe Layer-3 Remote UE that is connected to the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF for traffic transmission means the selected RSD has the component of preferred non-3GPP access type and the ProSe policy has the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF configurations. When it determines the indirect network path switching for another path selection, it follows the following steps:

* The 5G ProSe Layer-3 Remote UE shall still first perform the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF discovery and selection, if there is a 5G ProSe Layer-3 UE-to-Network Relay with N3IWF can be discovered and selected, the target indirect network path to be switched is 5G ProSe Layer-3 UE-to-Network Relay with N3IWF path. If not, the 5G ProSe Layer-3 Remote UE may re-evaluate the URSP and the RSD within it according to the precedence. During this process, if the same relay type is appeared again, the Remote UE evaluates the next RSD.

- After that, if the next selected RSD has component of "5G ProSe Layer-3 UE-to-Network Relay Offload indication", then the target indirect network path to be switched is 5G ProSe Layer-3 UE-to-Network Relay without N 3IWF path. Then the 5G ProSe Layer-3 Remote UE performs the 5G ProSe Layer-3 UE-to-Network Relay without N3IWF discovery and selection. If the next selected RSD has the preferred 3GPP access type and the ProSe policy has the 5G ProSe Layer-2 UE-to-Network Relay configurations, the target indirect network path to be switched is 5G ProSe Layer-2 UE-to-Network Relay path. Then the 5G ProSe Remote UE performs the 5G ProSe Layer-2 UE-to-Network Relay discovery and selection. If there are multiple 5G ProSe UE-to-Network Relay UEs can be selected, it depends on Remote UE’s implementation to perform the 5G ProSe UE-to-Network Relay UE selection.

### 6.14.4 Criteria for path switching for 5G ProSe Layer-2 relay

5G ProSe Layer-2 Remote UE that is connected to the 5G ProSe Layer-2 UE-to-Network Relay for traffic transmission means the selected RSD has the component of preferred 3GPP access type and the ProSe policy has the 5G ProSe Layer-2 UE-to-Network Relay configurations. When it determines the path switching, it follows the following steps:

* The 5G ProSe Layer-2 Remote UE shall first perform the 5G ProSe Layer-2 UE-to-Network Relay discovery and selection, if there is a 5G ProSe Layer-2 UE-to-Network Relay can be discovered and selected, the target indirect network path to be switched is 5G ProSe Layer-2 UE-to-Network Relay path. If not, the 5G ProSe Layer-2 Remote UE may re-evaluate the URSP and the RSD within it according to the precedence. During this process, if the same relay type is appeared again, the Remote UE evaluates the next RSD.

- After that, if the next selected RSD has component of "5G ProSe Layer-3 UE-to-Network Relay Offload indication", then the target indirect network path to be switched is 5G ProSe Layer-3 UE-to-Network Relay without N 3IWF path. Then the 5G ProSe Layer-2 Remote UE performs the 5G ProSe Layer-3 UE-to-Network Relay without N3IWF discovery and selection. If the next selected RSD has the preferred non-3GPP access type and the ProSe policy has the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF configurations, the target indirect network path to be switched is 5G ProSe Layer-3 UE-to-Network Relay with N3IWF path. Then the 5G ProSe Remote UE performs the 5G ProSe Layer-3 UE-to-Network Relay with N3IWF discovery and selection. If there are multiple 5G ProSe UE-to-Network Relay UEs can be selected, it depends on Remote UE implementation to perform the 5G ProSe UE-to-Network Relay UE selection.

### 6.14.5 Impacts on Existing Nodes and Functionality

The solution has impacts on the following entities:

UE(s):

- support of indirect network path selection based on the URSP and ProSe policy.

## 6.15 Solution #15: Service continuity support for path switch between two indirect network communication paths

### 6.15.1 General Description

This solution addresses KI#2 (as defined in clause 5.2) to support service continuity for a Remote UE connected to the network via a 5G ProSe UE-to-Network Relay (i.e. indirect network communication path) switch to another indirect network communication path, as shown in Figure 6.15.1-1.



Figure 6.15.1-1: Remote UE indirect-to-indirect path switch

As described in TS 23.304 [3], Remote UE connect to the network via Layer-3 UE-to-Network Relay or Layer-3 UE-to-Network Relay with N3IWF access or Layer-2 UE-to-Network relay and can switch between any of these indirect network communication paths.

Editor’s Note: Whether all the combinations of path switching (i.e. L2-L2, L2-L3, L3-L2, L3 with 2 variants) are needed is to be determined during conclusion phase.

### 6.15.2 Procedures

#### 6.15.2.1 Relay (re)selection

Target UE-to-Network Relay selection for path switch between indirect network communication paths is performed by the UE or network as below:

- Layer-3 Remote UE and Layer-2 Remote UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state select a target UE-to-Network Relay based on Remote UE controlled relay (re)selection procedures.

- Layer-2 Remote UE in CM-CONNECTED with RRC\_CONNECTED state is controlled by the network as part of the network controlled handover procedures as described in clause 6.15.2.2.

Layer-3 Remote UE with/without N3IWF and Layer-2 Remote UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state keep performing the PC5 unicast link measurements with its serving Relay to support Relay (re)selection, as specified in clause 6.5.3 of TS 23.304 [3]. When the NG-RAN configured measurement thresholds and the criteria for indirect-to-indirect path relay (re)selection are satisfied, the Remote UE performs the path switch to the target indirect network communication path. The target UE-to-Network Relay can be either connected to the same NG-RAN or different NG-RAN than the source UE-to-Network Relay.

Editor’s Note: The measurement trigger criteria for path switch between two indirect network communication paths will be defined by RAN WG.

If multiple UE-to-Network Relay UEs satisfy the Relay (re)selection criteria, the Layer-3 Remote UE select the target UE-to-Network Relay for path switch based on the 5G ProSe Policy or URSP rules and the Remote UE traffic handling described in clause 6.5.4 of TS 23.304 [3].

#### 6.15.2.2 Service Continuity

The service continuity procedures that can be supported when Remote UE path switch between indirect network communication paths differ based on whether both NAS and AS connections are setup for Remote UE on the source indirect communication path to the 5GS and whether both connections can be setup on the target indirect communication path to the 5GS.

**-** Layer-3 Remote UE switch from Layer-3 UE-to-Network Relay to another Layer-3 UE-to-Network Relay**:** Layer-3 Remote UE does not have any PDU session with 5GC when connected via Layer-3 UE-to-Network Relay without N3IWF access. Hence, application layer procedures is used for service continuity support. For example:

- Commercial IMS Services: IMS service continuity procedures specified in TS 23.237 [16].

- Missional Critical Services: service continuity procedures specified in Annex B of TS 23.280 [17], with the source path being an indirect communication path.

- Other services: application layer procedures specified outside of 3GPP scope can be utilized if available.

- Layer-3 Remote UE switch from Layer-3 UE-to-Network Relay with N3IWF support to an indirect network communication path with either a Layer-3 UE-to-Network Relay with N3IWF access or a Layer-2 UE-to-Network Relay: Layer-3 Remote UE connected to N3IWF can handover the existing PDU session to the target path. Hence, the handover procedures specified in clause 4.9.2 of TS 23.502 [8] for UE mobility between a 3GPP access and Untrusted non-3GPP access, are considered as baseline for session continuity support.

- Layer-2 Remote UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state performs path switch to an indirect network communication via Layer-2 UE-to-Network Relay: Existing mobility procedure can be used, and session continuity is supported with the existing procedures defined TS 23.502 [8].

- Layer-2 Remote UE in CM-CONNECTED state path switch to an indirect communication path via Layer-3 UE-to-Network Relay with N3IWF: Layer 2 Remote UE's PDU session(s) can handover to the indirect path via Layer-3 UE-to-Network Relay with N3IWF support. Thus, service continuity using the handover procedures specified in clause 4.9.2 of TS 23.502 [8] for UE mobility between a 3GPP access and Untrusted non-3GPP access, are considered as baseline for session continuity support.

- Layer-2 Remote UE in CM-CONNECTED state path switch to an indirect communication path via Layer-2 UE-to-Network Relay: Network controlled handover procedures defined for 3GPP access in clause 4.9.1 of TS 23.502 [8] are reused to support AS/NAS service continuity.

- When Xn interface is supported between the source NG-RAN and target NG-RAN, Xn based inter NG-RAN handover specified in clause 4.9.1.2 of TS 23.502 [8] are reused.

- When the Xn interface is not supported the source NG-RAN and target NG-RAN, Inter NG-RAN node N2 based handover specified in clause 4.9.1.3 of TS 23.502 [8] are reused.

Editor’s note: Intra-NG-RAN and Inter-NG-RAN AS handover procedures for path switch between Layer-2 UE-to-Network Relay indirect communication paths is defined by RAN WGs.

### 6.15.3 Impacts on Existing Nodes and Functionality

The solution has impacts in the following entities:

5GC entities (AMF, SMF, PCF, UPF):

- none.

NG-RAN:

- support indirect-to-indirect path relay (re)selection measurement criteria configuration

Remote UE:

- Remote UE needs to support handover procedures for untrusted non-3GPP access via N3IWF over L3 UE-to-NW Relay with N3IWF indirect communication path.

## 6.16 Solution #16: Provisioning policy based direct communication path switching between PC5 and Uu reference points

### 6.16.1 Description

This solution resolves Key Issue #3 "Support direct communication path switching between PC5 and Uu (i.e. non-relay case)" and Key Issue #6 "Support of PC5 Service Authorization and Policy/Parameter Provisioning".

The "direct communication path switching between direct PC5 and direct Uu reference points" refers to the procedure on how a UE switches the direct communication paths between PC5 reference point and Uu reference point when it is communicating with another UE. The direct communication path over direct PC5 reference point means that the communication with another UE is performed by using 5G ProSe Direct Communication only. The direct communication path over Uu reference point means that the communication with another UE is performed via the network (i.e. non-relay case) and the communication via 5G ProSe UE-to-Network Relay (Layer-2 or Layer-3) is not considered.

NOTE 1: Session continuity (e.g. IP address preservation) is not supported during path switching in this solution.

Path switching policy is provided to the UE to indicate which path(s) is allowed for all or specific ProSe services (i.e. direct PC5 allowed, direct Uu allowed or no allowed indicated). The path switching policy is defined as the mapping of ProSe services (i.e. ProSe identifiers) to path allowed (i.e. direct PC5 allowed, direct Uu allowed, or no allowed) and the path switching policy can be a one mapping for all ProSe services (i.e. same path allowed for all ProSe services).

The path switching policy can be (pre-) configured in the UE or provided by the PCF. The ProSe Application Server may provide a path allowed indication for ProSe Services to UDR and this may be used by PCF for path switching policy generation and update.

The UE may use the pre-configured/provisioned path switching policy to switching all or specific ProSe services to the appropriate communication path. The "Procedures for Service Authorization and Provisioning to UE" as defined in TS 23.304 [3] is reused for provisioning path switching policy to the UE.

The UE evaluates the path switching policy and switches the communication path as below:

- If direct PC5 allowed is indicated, the UE may switch to the direct PC5 reference point for communication path for the ProSe service.

- If direct Uu allowed is indicated, the UE may switch to the direct Uu reference point for communication path for the ProSe service.

- If no allowed is indicated or no path switching policy is provisioned, the UE may switch to either a direct Uu or direct PC5 communication path based on its pre-configuration or implementation for the ProSe service.

NOTE 2: The path switching policy is used to determine whether a communication path can be switched when a UE is communicating with another UE, so it is different to the path selection policy as defined in TS 23.304 [3].

Based on the path switching policy, a UE may establish a PDU session or a PC5 connection in the target path and switch the traffic from the source path to the target path. The service continuity during path switching can be achieved by the application layer mechanism.

### 6.16.2 Procedures

This clause describes the direct path switching procedures, including direct Uu to direct PC5 path switching and direct PC5 to direct Uu path switching.

Figure 6.16.2-1 depicts the procedure on direct Uu to direct PC5 path switching.



Figure 6.16.2-1: Procedure on direct Uu to direct PC5 path switching

1. UE-1 and UE-2 register to the network and establish PDU sessions respectively. The UE-1 and UE-2 communicate with each other via the established PDU sessions.

2. The UE-1 and UE-2 may decide to switch ProSe services from direct Uu path to direct PC5 path, due to, e.g. UE-1 and UE-2 are proximity to each other or to offload some traffic from the network.

UE-1 and UE-2 determine whether the ProSe services can be switched based on path switching policy as described in clause 6.16.1.

3. UE-1 and UE-2 establish PC5 connection by reusing the Layer-2 link establishment procedure as described in clause 6.4.3.1 of TS 23.304 [3].

4. The ProSe services are switched from direct Uu path to direct PC5 path.

5. The PDU session over direct Uu path may be released if no traffic transmitted over the PDU session.

Figure 6.16.2-2 depicts the procedure on direct PC5 to direct Uu path switching.



Figure 6.16.2-2: Procedure on direct PC5 to direct Uu path switching

1. UE-1 and UE-2 establish PC5 connection and communicate with each other via the direct PC5 path.

2. The UE-1 and UE-2 may decide to switch ProSe services from direct PC5 path to direct Uu path, due to, e.g. UE-1 and UE-2 are moving far with each other.

UE-1 and UE-2 determine whether the ProSe services can be switched based on path switching policy as described in clause 6.16.1.

3. UE-1 and UE-2 establish PDU sessions by reusing the PDU session establishment procedure as described in clause 4.3.2 of TS 23.502 [8].

4. The ProSe services are switched from direct PC5 path to direct Uu path.

5. The PC5 connection may be released if no traffic transmitted over the PC5 connection.

### 6.16.3 Impacts on Existing Nodes and Functionality

The solution has impacts on the following entities:

UE:

- UE needs to support the provisioned path switching policy as described in clause 6.16.1 to perform path switching between direct PC5 and direct Uu communication path.

PCF:

- PCF generates/updates path switching policy and provisions it to the UE.

ProSe Application Server:

- The ProSe Application Server may provide a path allowed for ProSe Services to UDR.

UDR:

- The UDR stores the path allowed and provides it to the PCF.

## 6.17 Solution #17: Path switching from PC5 path to Uu path

### 6.17.1 Description

This solution resolves Key Issue #3 for direct communication path switching from PC5 path to Uu path.

This solution uses the make-before-break mechanism to reduce interruption when path switch from PC5 to Uu. The two UEs perform the Uu path preparation procedure for the switched service, and then may release the PC5 connection. During the Uu path preparation procedure phase, the two UEs may negotiate, using the ProSe layer, the Uu QoS based on PC5 QoS via the PC5 connection in order to ensure consistent service experience, and optionally share the IP address used for the Uu path to each other to achieve the switch of service transmission.

### 6.17.2 Procedures



Figure 6.17.2-1: high-level procedure for path switch from PC5 to Uu

1. Triggered by an AF request, the PCF may provide the path switch Policy/parameters for Proximity Services to the UE (including UE1 and UE2) by using the procedure as defined in clause 4.2.4.3 in TS 23.502 [8]. The path switch Policy/parameters may include whether the specific service (e.g., Service A) is allowed to switch from PC5 to Uu.

2. UE1 and UE2 have an established PC5 connection and are transferring service data with each other for Service A. Before the PC5 connection establishment, UE1 and UE2 may get the path selection policy, which indicates that the PC5 path is preferred for Service A.

3. When e.g., the PC5 signal level is lower than the configured threshold or PC5 QoS for Service A cannot be satisfied, UE1 sends the path switch request for Service A to UE2. The request message includes the Service A identifier. Before UE1 sends the request, UE1 checks the path switch Policy/parameters to make sure that Service A is allowed to switch from PC5 to Uu.

4. UE2 sends the path switch response to UE1 that indicates that Service A can be switched to Uu path. The response message includes the Service A identifier. Before UE2 sends the response, UE2 checks the path switch Policy/parameters to make sure that Service A is allowed to switch from PC5 to Uu.

NOTE: PC5 connection is still valid to transfer the PC5 signalling in step 3 and step 4.

5. UE1 and UE2 perform the Uu path preparation procedure. In particular, UE1 and UE2 each trigger PDU Session establishment/modification procedure, if needed, to make the Uu path ready for Service A transmission. During this procedure UE1 and UE2 can get the IP address of the PDU session that will be used for the Service A, and UE1 and UE2 can respectively request the Uu QoS 1 (used for Uu path of UE1) and Uu QoS 2 (used for Uu path of UE2) for Service A .

Before UE1 and UE2 request the Uu QoS for Service A, UE1 decides the Uu QoS 1 and Uu QoS 2 requirements for Service A based on PC5 QoS requirement for Service A and sends Uu QoS 2 requirements to UE2 via the PC5 connection. Uu QoS 1 and Uu QoS 2 requirements can be decided based on the configured mapping of PC5 QoS parameter to Uu QoS parameter or based on UE1 implementation.

Optionally, UE1 and UE2 can also share the IP/port addresses used for Uu path with each other via the PC5 connection, to achieve the switch of the Service A transmission.

6. UE1 and UE2 transmit the data of the Service A via the Uu path.

7. After the step 6, UE1 and UE2 may release the PC5 connection, using the existing Layer-2 link release over PC5 reference point, see TS 23.304 [3], clause 6.4.3.3.

Editor’s Note: how to support Ethernet traffic and Unstructured traffic is FFS.

### 6.17.3 Impacts on services, entities and interfaces

**UE:**

- Support path switch procedure following the policy, including Uu path preparation procedure.

**PCF:**

- Composition of path switch policy.

## 6.18 Solution #18: UE Negotiation-based path switching from PC5 to Uu

### 6.18.1 Description

This is a solution related to the Key Issue #3 Support direct communication path switching between PC5 and Uu reference points.

This solution provides a UE Negotiation-Based mechanism for the direct communication path switching between PC5 to Uu reference points. Before performing the path switch, 2 UEs having PC5 connection negotiate the triggers of path switching and what service or QoS flows need to be switched. Once the negotiated triggers are satisfied, the 2 UEs perform the path switching between PC5 to Uu directly. To reduce the service interruption, the principle of “make before break” may be adopted, the 2 UEs may perform corresponding Uu session setup/activation in advance after the UE Negotiation-Based mechanism over PC5 for the path switching from PC5 to Uu interface. For the path switching from the Uu to PC5 interface, it requires that the 2 UEs establish the PC5 link firstly, then negotiate the ProSe services to be switched over the established PC5 link. After that, the 2 UEs perform the path switching based on the negotiated result.

During the negotiation procedure, the 2 UEs may negotiate:

* Which ProSe service to be switched;
* Which QoS flow(s) to be switched;
* Triggers of path switching from PC5 to Uu about:
  + Threshold of PC5 signal level
  + Threshold of QoS requirement/parameters

NOTE 1: In this solution, the negotiation can be triggered by UE implementation from the its own service requirement perspective.

NOTE 2: Granularity of this solution for path switching can be service level and QoS flow level.

Due to UE mobility or its own conditions (e.g. under congestion control, mobility restriction), the UE can not perform the path switch, then the UE may notify the peer UE of deactivating the negotiated triggers or UE ProSe policy of path switching to avoid the peer UE performing path switch solely.

### 6.18.2 Procedures for path switching from PC5 to Uu with negotiation



Figure 6.18.2-1: high-level procedure for path switch from PC5 to Uu with negotiation

1. Service authorization and provisioning are performed for the UE#1 and UE#2 as described in clause 6.2 of TS 23.304 [3].

2. UE#1 and UE#2 may have an established PC5 connection which are transferring service data with each other over PC5 QoS flows.

3. Considering to avoid service interruption, UE#1 and UE#2 may consider the path switch from PC5 to Uu. In order to have a uniform understanding for the path switch, the 2 UEs negotiate the path switching services, QoS flows and the triggers of the service or QoS flows to be switched. UE#1 sends a Path switching negotiation request which may include the ProSe ID, PC5 QoS flows IDs, Threshold of PC5 signal level, or Threshold of QoS requirement/parameters. This step can be combined with PC5 unicast connection establishment/modification procedure.

4. After receiving the above request from UE#1, UE#2 determines that services, QoS flows triggers and related triggers based on the Path switching negotiation request from the UE#1. The UE#2 responds to the UE#1 with a Path switching negotiation response including the accepted ProSe ID, PC5 QoS flows IDs, Threshold of PC5 signal level, or Threshold of QoS requirement/parameters.

5. Based on the negotiation, the UE#1 and UE#2 may perform the Uu path preparation procedure. UE1 and UE2 triggers PDU Session establishment/modification procedure to make the Uu path ready for the corresponding ProSe services or PC5 QoS flows transmission.

6~7. When the negotiated triggers/conditions are satisfied, the UE#1 and UE#2 transmit the data of the ProSe services of accepted ProSe IDs or the PC5 QoS flows of the accepted PC5 QoS flow IDs to the Uu path.

8. After the step 7, UE1 and UE2 may release the PC5 connection, using the existing Layer-2 link release over PC5 reference point, see TS 23.304 [3], clause 6.4.3.3.

UE#1 and UE#2 may update the negotiated triggers after the negation procedure.

### 6.18.3 Procedures of deactivating path switching



Figure 6.18.3-1: Negotiated triggers de-activate

1. After the path switch negotiation procedure as described in clause 6.18.2, the UE#1 and UE#2 store the accepted path switching triggers.

2. Due to mobility or other situations, the UE#1 can not perform the path switching from the PC5 to Uu, then the UE#1 may notify the UE#2 of deactivating the negotiated triggers. The UE#1 sends a Negotiated triggers de-activate notification to UE#2.

3. When the UE#2 received the notification from the UE#1, it deactivates the negotiated triggers determined in step1 and sends a response to UE#1.

### 6.18.4 Procedures for path switching from Uu to PC5 with negotiation



Figure 6.18.4-1: high-level procedure for path switch from Uu to PC5 with negotiation

1. Service authorization and provisioning are performed for the UE#1 and UE#2 as described in clause 6.2 of TS23.304[3].

2. UE#1 and UE#2 interacts the service data over the Uu path (PDU session) through the server with corresponding QoS flows.

3. The UE#1 and UE#2 may have the offload requirement from the Uu to PC5, then the 2 UEs may perform the direct discovery to discover each other as described in clause 6.3.2.1 of TS 23.304 [3].

4. When the 2 UEs discover each other, the UE#1 and UE#2 may establish a default direct unicast PC5 link as described in clause 6.4.3.1 of TS 23.304 [3].

5. The 2 UEs may further negotiate path switching (traffic handover) based on current situation (e.g. one of the 2 UEs is under mobility restriction or congestion control), UE#1 may send a Path switch negotiation request to the UE#2. In this request, it may include the ProSe IDs or traffic descriptor to reflect what service that the UE#1 would like to switch from the Uu to PC5.

6. UE#2 receives the Path switch negotiation request from the UE#1 and responds to UE#1 with the accept ProSe service.

7. Based on the negotiated result, the UE#1 and UE#2 may perform the direct link modification procedure over PC5 or re-establish a PC5 direct link for the service to be switched.

8. The 2 UEs may perform the Uu path modification, e.g., PDU session modification/release, or determine to not send the traffic data for service/application to be switched over the Uu.

9. The 2 UEs change the path of the traffic data for the service/application to be switched from the Uu to PC5.

### 6.18.5 Impacts on Existing Nodes and Functionality

The solution has impacts on the following entities:

UE(s):

- Support the negotiation Procedures for path switching between Uu and PC5and triggers de-activate procedure.

- have unified understanding of which traffic will be switched based on the negotiated triggers.

## 6.19 Solution #19: Path switching between PC5 and Uu reference points based on path permission policy

### 6.19.1 Description

This solution resolves Key Issue #3 about direct communication path switching between PC5 and Uu reference points.

One of the aspects on this key issue is described as:

What information/policy are used for path switching decision.

In clauses 5.1.3 and 5.11 of TS 23.304 [3], the communication path selection between PC5 and Uu reference points is described and the path selection policy is used to make decision on the communication path by the UE. The policy for path selection is based on the ProSe services as the following:

* If PC5 preferred is indicated, the UE should prefer to use the PC5 for communication path for the ProSe service.
* If Uu preferred is indicated, the UE should prefer to use the Uu for communication path for the ProSe service.
* If no preference is indicated or no path selection policy is provisioned, the UE selects either a Uu or PC5 communication path based on its pre-configuration or implementation for the ProSe service.

NOTE: When either PC5 preferred or Uu preferred is indicated, the UE can still select the other non-preferred path, e.g. because the peer UE is not in proximity.

In this solution, it is proposed to unify the path policy for both direct communication path selection and path switching and the policy will be path permission policy. The UE will evaluate the path permission policy before path selection or path switching operation.

### 6.19.2 Procedures

#### 6.19.2.1 Path permission policy description

The path permission policy includes the mapping of ProSe Services to the following path permission:

- PC5 permitted

- Uu permitted

- both PC5 and Uu permitted

The policy will be used for both direct communication path selection and path switching. For path selection, the description in clause 5.11 of TS 23.304 [3] is applied with the difference that PC5 or Uu "preferred" changes to PC5 or Uu "permitted", and when both PC5 and Uu permitted is indicated, the UE can select either a PC5 or a Uu communication path.

For path switching, when the UE communicates with another UE for a specific ProSe Service on either PC5 path or Uu path and finds the ongoing communication path cannot satisfy the ProSe Service, the UE will evaluate the path permission policy and operates as below:

- When only PC5 or only Uu permitted, the UE cannot switch to another communication path (from PC5 to Uu, or vice versa) for the ProSe Service.

- When both PC5 and Uu permitted, the UE can switch to another communication path (from PC5 to Uu, or vice versa) for the ProSe Service.

#### 6.19.2.2 Path permission policy provision procedure

The path permission policy can be (pre-) configured in the UE or provided by the PCF. The ProSe Application Server may provide a path permission for ProSe Services to UDR and this may be used by PCF for path permission policy generation and update.

The procedures for service authorization and provisioning to UE as defined in clause 6.2 of TS 23.304 [3] is reused for provisioning path permission policy to the UE.

#### 6.19.2.3 Path switching based on path permission policy procedure

Depicted in Figure 6.19.2.3-1 is the high-level procedure for path switching based on path permission policy.



**Figure 6.19.2.3-1: High-level path switching procedure based on path permission policy**

1. UE-1communicates with UE-2 for a ProSe Service on either PC5 path or Uu path.

2. The communication path (either PC5 or Uu) quality for the ongoing ProSe Service cannot satisfy the requirements of the ProSe Service.

3. UE-1 checks the path permission policy and finds the policy for the served ProSe Service is both PC5 and Uu path permitted. Then UE-1 decides to switch the ongoing communication path to another (from PC5 to Uu or vice versa).

4. If the old communication path is still valid, UE-1 may negotiate with UE-2 to confirm the switching of communication path.

NOTE: The signalling in Step. 4 is transported on the old communication path.

5. UE-1 and UE-2 switch the communication path to another (from PC5 to Uu or vice versa) and transmit the ProSe Service data on the new path.

6. UE-1 and UE-2 release the old communication path.

### 6.19.3 Impacts on Existing Nodes and Functionality

The solution has impacts on the following entities:

UE:

- Support receiving and storing the path permission policy;

- Perform path switching between PC5 and Uu communication path based on the path permission policy.

PCF:

- Provision the path permission policy to the UE.

ProSe Application Server:

- Provide a path permission for ProSe Services to UDR.

UDR:

- Store the path permission and provide it to the PCF.

## 6.20 Solution #20: Switching back from Uu path to PC5 path

### 6.20.1 Description

This is a solution for key issue #3 "Support direct communication path switching between PC5 and Uu (i.e. non-relay case)".

Two UEs can switch their communication path from PC5 to Uu because the PC5 signal strength of the unicast link between two UEs gets below configured signal strength threshold. In this case, there may be the case that two UEs will be able to communicate over PC5 reference point with the satisfactory signal strength after a while, e.g. as temporary obstacle between two UEs does not exist anymore. In order to switch back from Uu to PC5, two UEs need to establish a unicast link again after discovering each other over PC5 reference point. These tasks may take some time. In addition, when the UE(s) triggers ProSe Direct Discovery or Layer-2 link establishment may be uncertain if they want to communicate over PC5 reference point again.

Therefore, this solution proposes to reuse the unicast link when switching back from Uu to PC5 by maintaining the established unicast link after path switching to Uu. The maintained unicast link is also used to check whether switching back to PC5 path can be performed.

The outline of the proposed solution for switching back from Uu path to PC5 path is as below:

- After path switching from PC5 to Uu is made due to the PC5 signal strength of the unicast link lower than configured signal strength threshold, the unicast link between two UEs is not released but kept.

- One UE of the unicast link keeps checking the PC5 signal strength of the unicast link through the Layer-2 link maintenance procedure. Based on the checking results, the UE can determine whether to perform switching back to PC5 path as below:

- If the PC5 signal strength of the unicast link is considered good (i.e. not lower than configured signal strength threshold) during a configured time, the UE determines to perform switching back to PC5 path by reusing the unicast link.

- Otherwise, the UE determines not to perform switching back to PC5 path, thus, the unicast link is released.

- If the Layer-2 link maintenance procedure fails, e.g. because the UE initiating the procedure does not receive the Keep-alive Ack message from peer UE, the peer UE does not receive the Keep-alive message from the initiating UE, the unicast link is locally released.

NOTE: This solution does not preclude the switching back from Uu path to PC5 path without reusing the unicast link by releasing the unicast link after switching to Uu path.

### 6.20.2 Procedures

#### 6.20.2.1 Procedure for switch back from Uu path to PC5 path

Figure 6.20.2.1-1 shows the procedure for switching back from Uu path to PC5 path.



Figure 6.20.2.1-1: Procedure for switching back from Uu path to PC5 path

1. To communicate over PC5 reference point, UE-1 and UE-2 establish a Layer-2 link as specified in clause 6.4.3.1 of TS 23.304 [3]. UE-1 and UE-2 can exchange the data over the established unicast link.

2. When the PC5 signal strength of the unicast link is below configured signal strength threshold, path switching from PC5 to Uu is performed. UE-1 and UE-2 can exchange the data via the 5GC.

After path switching to Uu, UE-1 and UE-2 do not release the unicast link, so the unicast link is kept. During the Layer-2 link establishment procedure or the procedure for path switching from PC5 to Uu, UE-1 and UE-2 may negotiate whether to maintain the unicast link after path switching to Uu based on e.g. Path Selection policy (e.g. PC5 preferred), Path Switching policy (e.g. direct PC5 allowed).

NOTE 1: For details of path switching from PC5 to Uu, other solutions to propose it can be used. However, for this solution, the unicast link is maintained after path switching to Uu.

3. UE-1 initiates the Layer-2 link maintenance procedure by sending a Keep-alive message to UE-2 in order to determine the status of the PC5 unicast link as specified in clause 6.4.3.5 of TS 23.304 [3].

UE-1 starts a switch-back-attempt timer.

The switch-back-attempt timer may be provisioned in UE-1 as 5G ProSe Policy/Parameter.

4. UE-2 responds with a Keep-alive Ack message.

If the Layer-2 link maintenance procedure fails, e.g. because UE-1 does not receive the Keep-alive Ack message from UE-2, UE-2 does not receive the Keep-alive message from UE-1, the unicast link is locally released.

If UE-1 receives the Keep-alive Ack message from UE-2, UE-1 measures the PC5 signal level of the unicast link.

5. UE-1 may repeat the Layer-2 link maintenance procedure until the switch-back-attempt timer expires.

6. UE-1 determines whether to perform switching back to PC5 path based on the PC5 signal levels of the unicast link measured through the Layer-2 link maintenance procedures.

When UE-1 determines to perform path switching to PC5, steps 7 to 10 are performed.

7. UE-1 sends a Path Switch Request message to UE-2 to trigger path switching from Uu to PC5.

8. UE-2 responds with a Path Switch Response message.

After path switching from Uu to PC5 is completed, UE-1 and UE-2 can exchange the data over the unicast link.

NOTE 2: For path switching back to PC5, the Layer-2 link modification procedure as specified in clause 6.4.3.4 of TS 23.304 [3] can be performed following or instead of exchanging Path Switch Request/Response messages.

9. If the PDU Session used to communicate with UE-2 is not needed anymore after path switching to PC5, the PDU Session for UE-1 may be released.

10. If the PDU Session used to communicate with UE-1 is not needed anymore after path switching to PC5, the PDU Session for UE-2 may be released.

When UE-1 determines not to perform path switching to PC5, step 11 is performed.

11. The unicast link between UE-1 and UE-2 is released as specified in clause 6.4.3.3 of TS 23.304 [3].

NOTE 3: The unicast link between UE-1 and UE-2 can be released per request of the application layer.

### 6.20.3 Impacts on services, entities and interfaces

UE:

- supports switching back to PC5 path from Uu path by maintaining the unicast link after switching to Uu path and reusing the unicast link when switching back to PC5 path.

## 6.21 Solution #21: Support direct communication path switching between PC5 and Uu

### 6.21.1 Description

This solution addresses KI#3.

In clause 6.21.2, two procedures are depicted:

- Scenario A: This scenario addresses the case for direct communication path switching from Uu communication path to PC5 communication path between UE1 and UE2.

- Scenario B: This scenario addresses the case for direct communication path switching from PC5 communication path to Uu communication path between UE1 and UE2.

### 6.21.2 Procedures



**Figure 6.21.2-1: Scenario A: Path switch from Uu to PC5 communication path**

1. PCF subscribes to the UDR to receive notifications on ProSe Application parameter changes when there is a change of service specific parameter as described in clause 6.2.5 of TS 23.304 [3]. This may include either existing path selection policy, a modified path selection policy or a new path switching policy.

2.a-2c. ProSe Application Server invokes a “ServiceParameter\_Update” service operation through NEF. NEF stores the information within the UDR. PCF receives the notification of data change from the UDR (which it has already subscribed to in step 1.a). NEF responds on “ServiceParameter\_Update” to the ProSe Application Server.

3-4. PCF decides to update the UE ProSe policy and initiates policy update for both UE 1 and UE2.

Steps 1-4 are optional and can be skipped if the parameters already provisioned for ProSe policy are still valid.

5. UE1 discovers UE2 in proximity as part of application-level signalling with ProSe Application server or via ProSe Direct Discovery. UE1 decides on the path switch and sends direct communication request to initiate the unicast layer-2 link establishment incl. PC5 QoS parameters. UE2 accepts the request and confirms QoS Info and optionally PC5 QoS rule(s).

6. Following existing procedure in clause 4.3.7, TS 23.502 [8], the SMF may deactivate the UP connection of the relevant PDU sessions after a specified inactivity period leading to releasing UPF resources and AN-level resources via AMF. Alternatively, both UEs may initiate PDU session modification request for the pair of Uu links (over 5GC communication path) including a new parameter to indicate “PDU session to be deactivated”. If so, during deactivation procedure, the UPF of N3 terminating point is still maintained as described in the step 4 of clause, 4.3.7, TS 23.502 [8].

ProSe session continues over the direct link established between UE1 and UE2.



**Figure 6.21.2-2: Scenario B: Path switch from PC5 to Uu communication path**

1. PCF subscribes to the UDR to receive notifications on ProSe Application parameter changes when there is a change of service specific parameter as described in clause 6.2.5 of TS 23.304 [3]. This may include either existing path selection policy, a modified path selection policy or a new path switching policy.

2.a-2c. ProSe Application Server invokes a “ServiceParameter\_Update” service operation through NEF. NEF stores the information within the UDR. PCF receives the notification of data change from the UDR (which it has already subscribed to in step 1.a). NEF responds on “ServiceParameter\_Update” to the ProSe Application Server.

3-4. PCF decides to update the UE ProSe policy and initiates policy update for both UE 1 and UE2.

Steps 1-4 are optional and can be skipped if the parameters already provisioned for ProSe policy are still valid.

5. UE1 (or UE2) identify that they are not in proximity range of each other as part of application-level signalling with ProSe Application server or via ProSe Direct Discovery. Alternatively, UE1 (or UE2) identify that they cannot fulfil PC5 QoS requirements. In the latter case, UE1 (or UE2) requests (over PC5) for path switch to Uu path. This request also includes suggested QoS rules and QoS Flow level QoS parameters for Uu path mapped based on former the PC5 QoS parameters for the corresponding PC5 QoS Flow. UE2 (or UE1) accepts the path switch request.

6. Both UEs initiate PDU session establishment or modification request to switch to Uu communication path based on suggested QoS rules and QoS Flow level QoS parameters for Uu path in step 5.

7. Each UE (re)activates corresponding PDU session over Uu path following.

8. The AMF sends N2 PDU session (re-activation) request message to the R(AN).

9. (R)AN setups related AN-level resources.

PC5 connection is released and ProSe service continues over the Uu path between UE1 and UE2.

### 6.21.3 Impacts on services, entities and interfaces

UE:

- Support PC5 signalling for path switch including suggested QoS rules and QoS Flow level QoS parameters for Uu path.

- Optionally support PDU session deactivation indication.

PCF:

- Support changes to ProSe policy (for a modified path selection policy or path switching policy only).

SMF:

- Optionally support PDU session deactivation while maintaining the UPF of N3 terminating point.

6.22 Solution #22: Direct Communication Path switching between PC5 and Uu

6.22.1 Description

This solution resolves Key Issue #3 for direct communication path switching between PC5 and Uu.

6.22.2 Procedures

#### 6.22.2.1 Direct Communication Path switching from PC5 to Uu



**Figure 6.22.2.1-1: Path switching from PC5 to Uu**

0. UE1 and UE2 are provisioned with path switching policies (e.g. enabled/disabled, preferred interface, radio quality thresholds) by using the procedure as defined in clause 6.2 in TS 23.304 [3].

1. UE1 and UE2 establish a PC5 connection. During this procedure, the Path switching parameters (e.g. path switching enabled/disabled) are exchanged.

2. UE1 informs UE2 about its PDU session status (e.g. available for PDU session establishment) by using the PC5 Keepalive procedure.

3. UE2 informs UE1 about its PDU session status (e.g. available for PDU session establishment) by using the PC5 Keepalive procedure

Editor’s Note: Whether other ProSe signalling can be used for PDU session status exchange is FFS.

4. If UE1 determines to switch path from PC5 to Uu e.g. based on PC5 signal level and UE2’s PDU session status (i.e. PDU session establishment is available), UE1 sends a PC5 Path Switching Request message to UE2, including the path switching direction (i.e. PC5-to-Uu).

5. UE2 may establish a PDU session or modify an existing PDU session for switched traffic.

6. UE2 sends a PC5 Path Switching Response message to UE1, which includes the IP address associated to UE2’s PDU session.

7. UE1 may establish a PDU session or modify an existing PDU session for switched traffic.

8. UE1 sends a PC5 Path Switching Ack message to UE2, which includes the IP address associated to UE1’s PDU session. UE1 may send a PC5 Path Switching Abort message to abort the path switching procedure e.g., if the PDU session establishment/modification failed.

9. After the step 8, UE1 and UE2 may release the PC5 connection and use Uu path for communication.

Editor’s Note: how to support Ethernet traffic and Unstructured traffic is FFS.

#### 6.22.2.2 Direct Communication Path switching from Uu to PC5



**Figure 6.22.2.2-1: Path switching from Uu to PC5**

0. UE1 and UE2 are provisioned with path switching policies (e.g. enabled/disabled, preferred interface, radio quality thresholds) by using the procedure as defined in clause 6.2 in TS 23.304 [3]. UE1 and UE2 use Uu path for communication.

1. UE1 and UE2 establish a PC5 connection. During this procedure, the Path switching parameters (e.g. path switching enabled/disabled) are exchanged.

2. UE1 sends a PC5 Path Switching Request message, including the path switching direction (i.e. Uu-to-PC5) and the IP address associated to UE1’s PDU session.

3. UE2 sends a PC5 Path Switching Response message, including the IP address associated to UE2’s PDU session.

4. UE1 and UE2 use PC5 path for communication.

5. UE1 and UE2 may release/modify their PDU session.

Editor’s Note: how to support Ethernet traffic and Unstructured traffic is FFS.

6.22.3 Impacts on services, entities and interfaces

**UE:**

- Support path switch procedure.

**PCF:**

- Support path switch policy provisioning.

## 6.23 Solution #23: Session Continuity for path switching for L2 U2N Relay

### 6.23.1 Description

This solution addresses key issue 4 "Support of path switching between direct network communication path and indirect network communication path for Layer-2 UE-to-Network Relay with session continuity consideration". This solution has considered Xn based and N2 based HO proecedure applied for inter-gNB indirect-to-direct and inter-gNB direct-to-indirect path switching.

In this solution, the source gNB determines whether to switch to a direct cell or a L2 U2N relay UE. If the source gNB dertemines to switch to a L2 U2N relay UE, the source gNB selects the target L2 U2N relay UE for remote UE taken the authorized PLMN list for L2 U2N remote UE into account.

Editor’s note: For the inter-gNB cases which gNB (source or target) gNB selects a target Relay UE or direct Uu route depends upon RAN2 conclusion.

### 6.23.2 Procedures

#### 6.23.2.1 Xn based inter-gNB indirect-to-direct path switching

Figure 6.23.2.1-1 shows the procedure for Xn based inter-gNB indirect-to-direct path switching.



Figure 6.23.2.1-1：Procedure for Xn based inter-gNB indirect-to-direct path switching.

1. The remote UE performs the measurement and reporting procedure, this step is the same as step1 in clause 16.x.6.1 in TS 38.300 [15].

2. The gNB decides to switch the Remote UE onto direct Uu path in a different gNB.

3. The procedures are performed as specified in clause 4.9.1.2.2 of TS 23.502 [8].

4 and 5 are performed as step6 and step7 in clause 16.x.6.1 in TS 38.300 [15]

Editor’s note: The procedures have RAN dependency. The procedures are required to be evaluated by RAN WGs.

#### 6.23.2.2 Xn based inter-gNB direct-to-indirect path switching

Figure 6.23.2.2-1 shows the procedure for Xn based inter-gNB indirect-to-direct path switching.



Figure 6.23.2.2-1：Procedure for Xn based inter-gNB direct-to-indirect path switching.

1. The remote UE performs the measurement and reporting procedure, this step is the same as step1 in clause 16.x.6.2 in TS 38.300 [15].

2. The gNB decides to switch the U2N Remote UE to a target U2N Relay UE. The gNB selects a target U2N relay UE taken into the authorized PLMN list which is retrieved from AMF to select the target U2N relay UE.

3. The source gNB sends the Handover Request defined in TS 38.423 [18] in addition at least U2N Relay UE ID, U2N Relay UE's serving cell ID. The target gNB responds the Handover Request Ack defined in TS 38.413 [19].

Steps 4 to 7 are performed as steps 2 to 5 in clause 16.x.6.2 in TS 38.300 [15].

If the selected U2N Relay UE is in RRC\_IDLE or RRC\_INACTIVE, step 7 will trigger the U2N Relay UE to enter RRC\_CONNECTED state, then in this case step 7 will be performed before step 5.

8. The procedures are performed as steps 1b to 9 in clause 4.9.1.2.2 in TS 23.502 [8].

Editor’s note: The procedures have RAN dependency. The procedures are required to be evaluated by RAN WGs.

#### 6.23.2.3 N2 based inter-gNB indirect-to-direct path switching

Figure 6.23.2.3-1 shows the procedure for N2 based inter-gNB indirect-to-direct path switching.



Figure 6.23.2.3-1：Procedure for N2 based inter-gNB indirect-to-direct path switching.

1. The remote UE performs the measurement and reporting procedure, this step is the same as step1 in clause 16.x.6.1 in TS 38.300 [15].

2. The gNB decides to switch the Remote UE onto direct Uu path in a different gNB using N2 based handover.

3. The procedures are performed as steps 1 to 12 specified in clause 4.9.1.3.2 in TS 23.502 [8].

4. The procedures are performed as steps 1 to 15b specified in clause 4.9.1.3.3 in TS 23.502 [8].

Steps 5 and 6 are performed as step6 and step7 in clause 16.x.6.1 in TS 38.300 [15]

Editor’s note: The procedures have RAN dependency. The procedures are required to be evaluated by RAN WGs.

#### 6.23.2.4 N2 based inter-gNB direct-to-indirect path switching

Figure 6.23.2.4-1 shows the procedure for N2 based inter-gNB indirect-to-direct path switching.



Figure 6.23.2.4-1：Procedure for N2 based inter-gNB direct-to-indirect path switching.

1. The remote UE performs the measurement and reporting procedure, this step is the same as step1 in clause 16.x.6.2 in TS 38.300 [15].

2. The gNB decides to switch the U2N Remote UE to a target U2N Relay UE. The gNB selects a target U2N relay UE taken into the authorized PLMN list which is retrieved from AMF to select the target U2N relay UE.

3. The source gNB sends the Handover Required defined in TS 38.413 [19] in addition at least U2N Relay UE ID, U2N Relay UE's serving cell ID.

4. T-AMF selection: same as step 2 in clause 4.9.1.3.2 in TS 23.502 [8].

5. S-AMF to T-AMF: Namf\_Communication\_CreateUEContext Request is sent as specified in step 3 in clause 4.9.1.3.2 in TS 23.502 [8] in addition at least U2N Relay UE ID, U2N Relay UE's serving cell ID.

6. The procedures are performed as step 4 to 8 as specified in clause 4.9.1.3.2 in TS 23.502 [8].

7. T-AMF to T-RAN: Handover Request is sent as specified in step 9 in clause 4.9.1.3.2 in TS 23.502 [8] in addition at least U2N Relay UE ID, U2N Relay UE's serving cell ID.

8. This step is performed as step2 in clause 16.x.6.1 in TS 38.300 [15]

9. The procedures are performed as steps 10 to 12 as specified in clause 4.9.1.3.2 in TS 23.502 [8].

10. The procedures are performed as steps 1 to 3 as specified in clause 4.9.1.3.3 in TS 23.502 [8].

Step 11 and step 12 are performed as step 4 and step 5 in clause 16.x.6.2 in TS 38.300 [15].

If the selected U2N Relay UE is in RRC\_IDLE or RRC\_INACTIVE, step 7 will trigger the U2N Relay UE to enter RRC\_CONNECTED state, then in this case step 12 will be performed before step 8.

13. The procedures are performed as steps 5 to 15b in clause 4.9.1.3.3 in TS 23.502 [8].

Editor’s note: The procedures have RAN dependency. The procedures are required to be evaluated by RAN WGs.

### 6.23.3 Impacts on services, entities and interfaces

The solution has impacts in the following entities:

**gNB:**

- source gNB selects a target UE and sends the target UE info to AMF or target gNB.

**AMF:**

- Receives the target U2N relay UE info from gNB and AMF.

- Sends the target U2N relay UE info to gNB.

- Sends the authorized PLMN list to gNB.

## 6.24 Solution #24: Service continuity support for path switch between direct network communication path and indirect network communication path for Layer-2 UE-to-Network Relay

### 6.24.1 General Description

This solution addresses KI#4 (as defined in clause 5.4) to support service continuity for Layer-2 Remote UE path switch between direct network communication path and indirect network communication path via Layer-2 UE-to-Network Relay.



Figure 6.24.1-1: Layer 2 Remote UE path switch between direct and indirect network communication path via Layer-2 UE-to-Network Relay

As described in clause 6.5.2 of TS 23.304 [3], 5G ProSe Layer-2 Remote UE connected to the network via a Layer-2 UE-to-Network Relay UE has a NAS connection and AS layer (RRC) connection to 5GS, similar to a UE connected directly to the network. Thus, Layer-2 Remote UE can be in CM-IDLE or CM-CONNECTED with RRC\_CONNECTED or RRC\_INACTIVE state. In TS 23.502 [8], network controlled handover procedures are defined for handling the mobility of a UE in CM-CONNECTED with RRC\_CONNECTED state. These network controlled handover procedures are reused for UE path switch between a direct communication path and indirect communication path via Layer-2 UE-to-Network Relay connected to same NG-RAN or different NG-RAN.

Layer-2 Remote UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state can only support UE controlled handover procedures based on Relay (re)selection procedures.

### 6.24.2 Procedures

#### 6.24.2.1 Relay (re)selection

UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state, connected to the direct path or the indirect network communication path via Layer-2 UE-to-Network Relay performs the Uu link measurements or the PC5 unicast link measurements to perform Relay (re)selection, as specified in clause 6.5.3 of TS 23.304 [3]. When the NG-RAN configured measurement thresholds and the criteria for reselection from direct path to indirect path or from indirect path to direct path are satisfied, UE performs path switch and establishes connection over the target path. The target NG-RAN after the path switch may be the same NG-RAN or different NG-RAN than the source path.

If multiple UE-to-Network Relay UEs satisfy the Relay (re)selection criteria, the Layer-2 Remote UE select the target UE-to-Network Relay for path switch based on the 5G ProSe Policy and the Remote UE traffic handling described in clause 6.5.4 of TS 23.304 [3].

#### 6.24.2.2 Session Continuity

Layer-2 Remote UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state:

- When a UE in CM-IDLE or CM-CONNECTED with RRC\_INACTIVE state performs path switch between direct network communication path and indirect network communication via Layer-2 UE-to-Network Relay, the Remote UE selects the target Relay, and perform the mobility procedures as defined in TS 23.502 [8].

Editor's Note: It is FFS whether there is RAN impacts when the Remote UE in RRC\_INACTIVE state resumes RRC connection via a Layer-2 UE-to-Network Relay.

Layer-2 Remote UE in CM-CONNECTED state:

- Network controlled handover procedures defined for 3GPP access in clause 4.9.1 of TS 23.502[8] are reused to support AS/NAS session continuity for Layer-2 Remote UE in CM-CONNECTED state path switch between direct network communication path and indirect network communication path via Layer-2 UE-to-Network Relay.

- When Xn interface is supported between the source NG-RAN and target NG-RAN, Xn based inter NG-RAN handover specified in clause 4.9.1.2 of TS 23.502 [8] are reused.

- When the Xn interface is not supported the source NG-RAN and target NG-RAN, Inter NG-RAN node N2 based handover specified in clause 4.9.1.3 of TS 23.502 [8] are reused.

NOTE: Intra-NG-RAN and Inter-NG-RAN AS layer handover procedures for path switch between direct network communication path and indirect network communication path via Layer-2 UE-to-Network Relay are defined by RAN WGs.

### 6.24.3 Impacts on Existing Nodes and Functionality

The solution has impacts in the following entities:

5GC entities (AMF, SMF, PCF, UPF):

- None.

NG-RAN:

- support the Handover procedures in 3GPP access as defined in TS 23.502 [8] with the Remote UE connected via a Layer-2 UE-to-Network Relay.

Remote UE:

- None.

## 6.25 Solution #25: Authorization for Multi-path Transmission via UE-to-Network Relay and direct Uu using URSP

### 6.25.1 Description

This solution addresses KI#5 and 6, applies to both Layer-2 and Layer-3 UE-to-UE Relay.

For KI#5, following aspects are covered:

- Whether and how to authorise a Remote UE to use the multi-path transmission for specific ProSe service(s).

- How to provide/update the rules for multiple-path transmission.

For KI#6 (Support of PC5 Service Authorization and Policy/Parameter Provisioning), two following major aspects are covered:

- What are necessary enhancements for the procedures related to PC5 service authorization and policy/parameter provisioning to a UE, compared with what is currently specified in TS 23.304 [3] clause 5.1 and TS 23.502 [8] clause 4.2.2.2 (Registration Procedure), 4.2.4.3 (UE Configuration Update procedure for transparent UE Policy Delivery), 4.16.11 (UE Policy Association Establishment procedure), 4.16.12 (UE Policy Association Modification procedure).

- what is new information for PC5 service authorization and provisioning beyond what is currently specified in TS 23.304 [3] clause 5.1.

The PCF based service authorization and provisioning as defined in TS 23.304 [3] are used as baseline for this solution.

### 6.25.2 Procedures

#### 6.25.2.1 Procedure Enhancement for Multi-path Policy Provisioning to a 5G ProSe Remote UE

For PCF based Service Authorization and Provisioning to 5G ProSe Remote UE/UE-to-UE Relay, the Registration procedures as defined in clause 4.2.2.2 of TS 23.502 [8], UE Policy Association Establishment procedure as defined in clause 4.16.11 of TS 23.502 [8] and UE Policy Association Modification procedure as defined in clause 4.16.12 of TS 23.502 [8] apply with the following additions:

- If the UE supports Multi-path transmission and 5G ProSe capability as a Remote UE accessing UE-to-Network Relay and it does not have valid Multi-path policy, the UE includes the UE Policy Container with indicating the Multi-path policy provisioning request during registration procedure.

- If the UE indicates the Multi-path policy provisioning request in the UE Policy Container, the PCF determines whether to provision the Multi-path policy to the UE accessing Layer-2 or Layer-3 UE-to-Network Relay based on the received capability of 5G ProSe Layer-2 or Layer-3 Remote UE from AMF, as specified in clause 6.1.2.2.2 of TS 23.503[13], and the PCF provides the Multi-path policy to the UE by using the procedure as defined in clause 4.2.4.3 "UE Configuration Update procedure for transparent UE Policy Delivery" in TS 23.502 [8].

#### 6.25.2.2 The Multi-path Policy to a 5G ProSe Remote UE using URSP

Table 6.25.2.2-1 (Table 6.6.2.1-3 in TS 23.503 [13]): Route Selection Descriptor

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Information name | Description | Category | PCF permitted to modify in URSP | Scope |
| Route Selection Descriptor Precedence | Determines the order in which the Route Selection Descriptors are to be applied. | Mandatory (NOTE 1) | Yes | UE context |
| **Route selection components** | *This part defines the route selection components* | Mandatory (NOTE 2) |  |  |
| SSC Mode Selection | One single value of SSC mode.  (NOTE 5) | Optional | Yes | UE context |
| Network Slice Selection | Either a single value or a list of values of S-NSSAI(s). | Optional  (NOTE 3) | Yes | UE context |
| DNN Selection | Either a single value or a list of values of DNN(s). | Optional | Yes | UE context |
| PDU Session Type Selection | One single value of PDU Session Type | Optional  (NOTE 8) | Yes | UE context |
| Non-Seamless Offload indication | Indicates if the traffic of the matching application is to be offloaded to non-3GPP access outside of a PDU Session. | Optional  (NOTE 4) | Yes | UE context |
| ProSe Layer-3 UE-to-Network Relay Offload indication | Indicates if the traffic of the matching application is to be sent via a ProSe Layer-3 UE-to-Network Relay outside of a PDU session. | Optional  (NOTE 4) | Yes | UE context |
| Access Type preference | Indicates the preferred Access Type (3GPP or non-3GPP or Multi-Access) when the UE establishes a PDU Session for the matching application. | Optional | Yes | UE context |
| **Multi-Path preference** | **Indicates the Multi-Path PDU Sessions via direct Uu and Layer-2/3 UE-to-Network Relay is preferred** | **Optional** | **Yes** | **UE context** |
| PDU Session Pair ID | An indication shared by redundant PDU Sessions as described in clause 5.33.2.1 of TS 23.501 [2]. | Optional | Yes | UE context |
| RSN | The RSN as described in clause 5.33.2.1 of TS 23.501 [2]. | Optional | Yes | UE context |
| **Route Selection Validation Criteria**  (NOTE 6) | *This part defines the Route Validation Criteria components* | Optional |  |  |
| Time Window | The time window when the matching traffic is allowed. The RSD is not considered to be valid if the current time is not in the time window. | Optional | Yes | UE context |
| Location Criteria | The UE location where the matching traffic is allowed. The RSD rule is not considered to be valid if the UE location does not match the location criteria. | Optional | Yes | UE context |
| NOTE 1: Every Route Selection Descriptor in the list shall have a different precedence value.  NOTE 2: At least one of the route selection components shall be present.  NOTE 3: When the Subscription Information contains only one S-NSSAI in UDR, the PCF needs not provision the UE with S-NSSAI in the Network Slice Selection information. The "match all" URSP rule has one S-NSSAI at most.  NOTE 4: If this indication is present in a Route Selection Descriptor, no other components shall be included in the Route Selection Descriptor.  NOTE 5: The SSC Mode 3 shall only be used when the PDU Session Type is IP.  NOTE 6: The Route Selection Descriptor is not considered valid unless all the provided Validation Criteria are met.  NOTE 7: In this Release of specification, inclusion of the Validation Criteria in Roaming scenarios is not considered.  NOTE 8: When the PDU Session Type is "Ethernet" or "Unstructured", this component shall be present. | | | | |

* ProSe Layer-3 UE-to-Network Relay Offload indication: Indicates that the traffic of the matching application is to be sent via a ProSe Layer-3 UE-to-Network Relay outside of a PDU Session when the rule is applied. If this indication is absent then the traffic matching of the URSP rule shall not be sent via a ProSe Layer-3 UE-to-Network Relay outside of a PDU Session. If this component is present without Multi-Path preference indication in a Route Selection Descriptor, no other components shall be included in the Route Selection Descriptor. If this component is present with Multi-Path preference indication in a Route Selection Descriptor, other components can be included in the Route Selection Descriptor.
* Multi-Path preference: If the UE needs to establish PDU Sessions, it indicates such operation via direct Uu and Layer-2/3 UE-to-Network Relay is preferred.

When the UE has a Layer-2/3 UE-to-Network Relay path available and establishes a PDU Session, it evaluates the matched URSP rule for application traffic and decides whether to use Multi-Path PDU Session for the application traffic based on the Multi-Path preference in the Route Selection Descriptor of a URSP rule.

### 6.25.3 Impacts on services, entities and interfaces

UE:

- Includes the UE Policy Container with indicating the Multi-path Policy Provisioning request during registration procedure;

- Receive and enforce the Multi-path Policy.

PCF:

- Determine and Send the Multi-path Policy to 5G ProSe Remote UE.

## 6.26 Solution #26: Multi-path transmission via Layer-2 UE-to-Network Relay

### 6.26.1 Description

This solution resolves Key Issue #5 Support of multi-path transmission via Layer-2 UE-to-Network Relay. As illustrated in figure 6.26.1-1, a (Remote) UE can use path #1 and path #2 for multi-path transmission between the UE and NG-RAN, where path #1 is direct network communication path (the UE directly accesses NG-RAN), and path #2 is indirect network communication path via a Layer-2 UE-to-Network Relay (the UE accesses NG-RAN using a Layer-2 UE-to-Network Relay). For the Layer-2 UE-to-Network Relay case, NG-RAN controls the multi-path connection establishment and the specific transmission such as splitting or duplication.



Figure 6.26.1-1: multi-path transmission using Layer-2 UE-to-Network Relay

This solution proposes a high-level procedure for multi-path transmission via Layer-2 UE-to-Network Relay and coordination with RAN2 WG is needed for solution alignment and update based on RAN2 progress and normative work.

### 6.26.2 Procedures



Figure 6.26.2-1: high-level procedure for Multi-path transmission via Layer-2 U2N Relay

1. The Remote UE may get the authorization/policy from the PCF or be preconfigured with an indication that that the Remote UE is authorized for multi-path transmission via a Layer-2 UE-to-Network Relay. When the Remote UE is in CM-CONNECTED state, the Remote UE’s serving NG-RAN may get the authorization information from AMF to indicate whether the Remote UE is allowed to use multi-path transmission via Layer-2 UE-to-Network Relay, and AMF gets the authorization information from UDM as part of the subscription data for 5G ProSe services.

2. The Remote UE sets up a RRC connection via either a direct or indirect path to NG-RAN. For indirect path, steps 0-6 within the procedure as defined in clause 6.5.2.2 in TS 23.304 [3] are performed.

3. During PDU session establishment/modification procedure, NG-RAN can decide that multi-path transmission for a QoS flow can be performed during or after a QoS Flow establishment, considering the authorization/policy in step 1.

4. NG-RAN sets up an AS connections to the Remote UE via both the direct network communication path and the indirect network communication path and then NG-RAN transfer of data over the QoS flow with the Remote UE using the dual paths.

Editor’s note: How the AS connections are established depends on RAN2 WG.

### 6.26.3 Impacts on services, entities and interfaces

**Remote UE:**

- Multi-path connection establishment and the transfer of data via both paths.

**NG-RAN:**

- Multi-path connection establishment and the transfer of data via both paths, taking into account authorisation from AMF.

**AMF:**

- Provide authorisation to NG-RAN.

## 6.27 Solution #27: Remote UE traffic handling for Multi-Path with Layer-3 relay without N3IWF

### 6.27.1 Description

This solution is related to the Key Issue #5: Support of multi-path transmission for UE-to-Network Relay, and it mainly focuses on the support for one direct network communication path and one indirect network communication path via Layer 3 UE-to-Network Relay without N3IWF.

In this solution, the triggers for the 5G ProSe Remote UE to determine to use multi-path with can be the following:

- Application provides multi-path requirements;

- UE ProSe policy, UE ProSe policy contains multi-path usage indication which can be pre-configured or configured by the network;

- UE implementation, e.g., based on the application layer high QoS requirement.

When the 5G ProSe Remote UE determines to use the multi-path transmission based on the above triggers, the 5G ProSe Remote UE still follows the traffic handling for 5G ProSe UE-to-Network Relay support as described in clause 6.5.4 in TS 23.304 [3].

When to decide to use multi-path transmission with including the 5G ProSe Layer-3 relay without N3IWF path, the 5G ProSe Remote UE should have same understanding on the PDU session parameters usage on the direct network path and indirect network path, details can be seen in clause 6.27.2.

### 6.27.2 Procedure for Remote UE traffic handling for Multi-Path with Layer-3 relay without N3IWF



**Figure 6.27.2-1:** **Multi-path transmission with using 5G ProSe UE-to-Network Relay without N3IWF**

As described in clause 6.5.4 of TS 23.304 [3], the application traffic on the 5G ProSe Remote UE is managed by URSP rules, the 5G ProSe Remote UE to use the 5G ProSe UE-to-Network Relay without N3IWF path based on the selected RSD containing the component of "5G ProSe Layer-3 UE-to-Network Relay Offload indication". When to consider multipath transmission, following may be some steps to determine PDU session parameters of another path:

* If the selected RSD contains the "5G ProSe Layer-3 UE-to-Network Relay Offload indication", then the indirect network path is 5G ProSe Layer-3 UE-to-Network Relay, then to determine the direct network path,

- The 5G ProSe Remote UE determines the PDU session parameters (PDU Session type, DNN, SSC Mode, S-NSSAI, Access Type Preference) based on the UE ProSe policy as described in clause 5.1.4.1 of TS 23.304 [3].

- The 5G ProSe Remote UE takes the above determined PDU session parameters as the PDU session parameters of the direct network path, and to evaluate the existing PDU sessions, or establish a new PDU session.

* If the selected RSD does not contain the "5G ProSe Layer-3 UE-to-Network Relay Offload indication" and it determines to use direct network path as the first path, then to determine the indirect network path,

- If there is the configurations for 5G ProSe Layer-3 UE-to-Network Relay without N3IWF and the 5G ProSe Layer-3 UE-to-Network Relay without N3IWF is selected as the indirect path, the 5G ProSe Layer-3 Remote UE takes UE ProSe policy as described in clause in clause 5.1.4.1 of TS 23.304 [3] to determine the RSC and corresponding PDU session parameters for the indirect network path setup.

NOTE: Multi-path including Layer-3 relay without N3IWF establishment procedure is to be addressed in other solutions.

### 6.27.3 Impacts on Existing Nodes and Functionality

The solution has impacts on the following entities:

UE(s):

- support multi-path transmission.

- can determine the PDU session parameters based on another path without URSP evaluation for multi-path transmission with including the 5G ProSe Layer-3 relay without N3IWF path.

## 6.28 Solution #28: Multi-path transmission support for one direct path and one indirect network communication path

### 6.28.1 General Description

This is a solution to support KI#5 (as defined in clause 5.5) multi-path transmission for a UE using one direct network communication path and one indirect network communication path, as shown in Figure 6.28.1-1. Indirect network communication path can be via a Layer-3 UE-to-Network Relay with or without N3IWF access or Layer-2 UE-to-Network Relay.

UE

UE-to-Network Relay

NG-RAN

Data network

NG-RAN

5GC

PC5

Uu

Uu

N2/N33

N2/N33

N6

Xn

Figure 6.28.1-1: Multi-path transmission using a direct Uu path and indirect network communication path

Supporting multi-path connectivity using 3GPP features like ATSSS or Multi-Radio Dual Connectivity (MR-DC) is dependent on whether the Remote UE has an AS connection or NAS connection with the Network.

Layer-3 Remote UE does not have a 5G connection when connected via Layer-3 UE-to-Network Relay without N3IWF as defined in TS 23.304 [3] clause 6.5.1.1. Thus, Application layer mechanisms are used to support multi-path transmission for Layer-3 Remote UE. Application layer can decide when to setup the multi-path connectivity and how to aggregate/split the traffic on both paths.

On the other hand, when the Layer-3 Remote UE access the network via a Layer-3 UE-to-Network Relay with N3IWF support, as defined in TS 23.304 [3] clause 6.5.1.2, it has NAS connection with the 5GC and PDU session will be used for the application traffic. The ATSSS feature supports a multi-access PDU Connectivity Service, which can exchange PDUs between the UE and a data network by simultaneously using one 3GPP access network and one untrusted non-3GPP access network and two independent N3/N9 tunnels between the PSA and RAN/AN. As the Layer-3 Remote UE connection via Layer-3 UE-to-Network Relay with N3IWF is considered as "*untrusted non-3GPP access to 5GC via N3IWF"*, ATSSS feature can be used to support multi-path transmission for Layer-3 Remote UE connected to network using one 3GPP access network (i.e. direct path) and one non-3GPP access network (i.e. indirect path via Layer-3 UE-to-Network Relay with N3IWF), as shown in Figure 6.28.1-2.

UE

UE-to-Network Relay

NG-RAN

Data network

NG-RAN

5GC

PC5

Uu

Uu

N2/N33

N2/N33

N6

Xn

N3IWF

**MA PDU Session over 3GPP access (i.e. direct path)**

**MA PDU Session over non-3GPP access (i.e. indirect path)**

Figure 6.28.1-2: Multi-path transmission using ATSSS for a direct path and indirect path via Layer-3 UE-to-Network Relay with N3IWF

Layer-2 Remote UE has a NAS connection and AS connection, similar to a UE connected directly to the network via Uu connectivity. Multi-Radio Dual Connectivity (MR-DC) is supported in NG-RAN to allow multi-path transmission for a UE connected to the network via two access nodes. Similar approach can be introduced to support multi-path transmission for a CM-CONNECTED Layer-2 Remote UE that has an AS connection via direct network communication path and indirect network communication path. The operation details of the MR-DCis within RAN WG scope.

Editor’s Note: SA2 WG to coordinate with RAN2 WG on support of multi-path transmission for Layer-2 Remote UE to determine the impacts for 5GC.

### 6.28.2 Procedures

### 6.28.2.1 Procedures for MA PDU sessions support for Layer-3 Remote UE

Figure 6.28.2.1-1 provides the procedures for MA PDU session setup by the UE over direct network communication path and indirect network communication path via a Layer-3 UE-to-Network Relay with N3IWF.

Remote UE

UE-to-NW Relay

NG-RAN

AMF

SMF

UPF

1.5GS registration and/or PDU session connectivity (UE ProSe policy)

1.5GS registration, authorization, and provisioning (UE ProSe policy, URSP)

2. MA PDU session establishment over direct path (ATSSS rules)

3. Indirect network communication path connection establishment via Layer-3 UE-to-Network relay with N3IWF using the procedures in clause 6.5.1.2 of TS 23.304 [3]

4. MA PDU session establishment over indirect path (ATSSS rules update)

Figure 6.28.2.1-1: MA-PDU Session establishment over direct network communication path and indirect network communication path via a Layer-3 UE-to-Network Relay with N3IWF

1. 5G ProSe Layer-3 UE-to-Network Relay and Layer-3 Remote UE perform Registration procedures and obtains the ProSe Policy that corresponds to the operation supporting the access to N3IWF.

The 5G ProSe Layer-3 Remote UE is configured with the corresponding URSP rules. The URSP policy indicates if a particular service needs to be accessed within a PDU Session and thus should use a 5G ProSe Layer-3 UE-to-Network Relay with N3IWF support as described in clause 6.5.4 of TS 23.304 [3].

2. Layer-3 Remote UE establishes a MA PDU session for services requiring multi-path transmission over the direct network communication path, using the procedures for 3GPP access in clause 4.22 of TS 23.502 [8].

3. Layer-3 Remote UE, if not connected and registered to the network via a Layer-3 UE-to-Network Relay with N3IWF, performs relay (re)selection and performs registration with 5GC using the procedures in clause 6.5.1.2 of TS 23.304 [3].

4. Layer-3 Remote UE performs MA PDU Session Establishment procedure or adds the user plane resources over the indirect network communication path using the procedures in clause 4.22 of TS 23.502 [8].

### 6.28.3 Impacts on Existing Nodes and Functionality

5GC entities (AMF, SMF, PCF, UPF):

- support the ATSSS feature as defined in TS 23.502 [8].

NG-RAN:

- support multi-path connectivity for Layer-2 Remote UE via one direct network communication path and one indirect network communication path as specified by RAN.

Remote UE:

- For Layer-3 relaying: support the ATSSS feature as defined in TS 23.502 [8].

* For Layer-2 relaying: support multi-path connectivity over one direct network communication path and one indirect network communication path via Layer-2 UE-to-Network Relay as specified by RAN.

## 6.29 Solution #29: multi-path transmission for UE-to-Network Relay

### 6.29.1 Description

In this solution, it proposes to reuse existing procedure as much as possible. It is assumed that the UE subscribes to the multi-path transmission service. And network can provision the authorization and policy parameters for multi-path transmission service to UE as existing mechanism specified in TS 23.304 [3].

Editor's note: the details for how to provision the authorization and policy parameters for multi-path transmission service is FFS.

Editor's note: whether this solution applys L2 is FFS

Editor's note: how to subscribe to the multi-path transmission service is FFS

### 6.29.2 Procedures

In case A, UE has established Uu connection to deliver traffic to the target DN. When UE is authorized to use the multi-path transmission service. UE triggers to discover the UE-to-Network Relay and try to establish connection to the same target for data traffic as existing mechanism specified in TS 23.304 [3].

In case B, UE has established 3GPP connection to the target DN via UE-to-Network Relay. When UE is authorized to use the multi-path transmission service. UE triggers to establish 3GPP connection via Uu as specified in TS 23.502 [8], e.g., establishing PDU session to deliver the traffic to the same DN.

For both case A and case B, How to integrate the traffic from both Uu connection and connection via UE-to-Network Relay is up to application layer.

### 6.29.3 Impacts on services, entities and interfaces

No impact on 3GPP.

## 6.X Solution #X: <Solution Title>

### 6.X.1 Description

Editor's note: This clause will describe the solution principles and architecture assumptions for corresponding key issue(s). (Sub-) clause(s) may be added to capture details.

### 6.X.2 Procedures

Editor's note: This clause describes services and related procedures for the solution.

### 6.X.3 Impacts on services, entities and interfaces

Editor's note: This clause captures impacts on existing services, entities and interfaces.

# 7 Overall Evaluation

Editor's note: This clause will provide evaluation of different solutions.

# 8 Conclusions

Editor's note: This clause will list conclusions that have been agreed during the course of the study item activities.

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 UE-to-UE Relay UE.

## A.2 Control and User Plane Protocols for Layer 2 UE-to-UE Relay

### A.2.1 User Plane Protocol Stack

Figure A.2.1-1 illustrates user plane protocol stacks using a UE-to-UE Layer-2 Relay. The security is established end-to-end 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 the relayed packets.



Figure A.2.1-1: End-to-End User Plane protocol stacks using a Layer-2 UE-to-UE Relay

Both IP traffic and Non-IP traffic are supported.

The SDAP and PDCP protocols above are as specified in TS 38.300 [15].

### A.2.2 Control Plane Protocol Stack

Figure A.2.2-1 illustrates control plane protocol stacks using a Layer-2 UE-to-UE Relay. The security is established end-to-end between UE1 and UE2 as shown by the PDCP layer terminating in UE1 and UE2. Therefore, the E2E PC5-S message between UE1 and UE2 is never exposed at the relay node since the relay function does not process/apply any security on the relayed E2E PC5-S messages.



Figure A.2.2-1: End-to-End Control Plane protocol stacks using a Layer-2 UE-to-UE Relay

NOTE 1: The definition and functionalities of the Adaptation Layer are defined by RAN WG2.

NOTE 2: Only the End-to-End control plane protocol stack is shown in Figure A.2.2-1. The control plane protocol stack of the unicast link between UE1/UE2 and UE-to-UE Relay (i.e. PC5 unicast link) can re-use the regular PC5-S protocol stack defined in clause 6.1.2 in TS 23.304 [3].

NOTE 3: PC5-S messages from direct PC5 unicast link with the UE-to-UE Relay and for E2E PC5 unicast link are supported. The E2E PC5-S message is the message transferred between UE1 and UE2, and the direct PC5-S message is the message transferred between UE1 and UE-to-UE Relay or between UE-to-UE Relay and UE2. How to differentiate them depends on RAN solution. Whether the same pair of source and destination Layer-2 IDs is used for direct and E2E PC5-S messages is to be determine during SA WG2's normative phase and it's feasibility is to be confirmed by RAN2.

Annex B:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-02 | SA2#149 | S2-2200739 | - | - | - | Proposed skeleton agreed at SA2#149e | 0.0.0 |
| 2022-02 | SA2#149 |  |  |  |  | Inclusion of documents approved in SA2#149e:  S2-2200740, S2-2201366, S2-2201367, S2-2201368, S2-2201369, S2-2201370, S2-2201371, S2-2201372, S2-2201373 | 0.1.0 |
| 2022-02 | SA2#149 |  |  |  |  | MCC correction to clause 5.6.1 | 0.1.1 |
| 2022-04 | SA2#150 |  |  |  |  | Inclusion of documents approved in SA2#150E:  S2-2203131, S2-2202463, S2-2202323, S2-2203132, S2-2203133, S2-2203134, S2-2203135, S2-2203150, S2-2203136, S2-2203137, S2-2202326, S2-2203138, S2-2203139, S2-2203140, S2-2203141, S2-2203142, S2-2203143, S2-2203144, S2-2203415, S2-2202416, S2-2203146, S2-2203148, S2-2203149. | 0.2.0 |