SA WG2 Meeting #162 S2-2404323

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**Source: OPPO**

**Title: KI#2 solution#6 update for multi-hop UE-to-UE Relays**

**Document for: Approval**

**Agenda Item: 19.7**

**Work Item / Release: FS\_5G\_ProSe\_Ph3/Rel-19**

*Abstract of the contribution: This contribution proposes update to solution#6.*

# 1. Discussion

The paper proposes an update to solution#6 to include a multi-hop authorization info per RSC. The RSC and the multi-hop authorization info are provided to the End UEs and UE-to-UE Relays using the Policy/Parameter provisioning as described in clause 5.1.5 of TS 23.304 [4].

The multi-hop authorization info includes:

- Whether multi-hop UE-to-UE Relay is allowed;

- The maximum number of hops supported;

- The maximum delay allowed.

With the proposed multi-hop authorization info, RSC in the discovery messages can be used to indicate whether multi-hop UE-to-UE Relay is allowed, the limit of number of hops and the delay allowed. Thus, the explicit parameters including multi-hop indication, maximum number of hops allowed and maximum delay allowed can be removed from the discovery messages.

# 2. Text proposal

It is proposed to agree the following changes to TR 23.700-03:

\* \* \* Start of change \* \* \*

## 6.6 Solution #6: Multi-hop extension of 5G ProSe UE-to-UE Relay

### 6.6.1 Description

In this solution, 5G ProSe multi-hop Layer-3 UE-to-UE Relay over NR PC5 is supported with the following principles:

- Authorization and configuration

- For supporting multi-hop extension, a UE-to-UE Relay shall be authorized and configured as a UE-to-UE Relay with multi-hop extension.

- For each RSC, the associated multi-hop authorization info are provided to the End UEs and UE-to-UE Relays using the Policy/Parameter provisioning as described in clause 5.1.5 of TS 23.304 [4]. The multi-hop authorization info includes:

- Whether multi-hop UE-to-UE Relay is allowed;

- The maximum number of hops supported;

- The maximum delay allowed.

- Multi-hop UE-to-UE Relay Discovery

- Model A and Model B discovery can be used for multi-hop UE-to-UE Relay discovery. When supporting multi-hop discovery, Announcement message for model A discovery and Solicitation and Response messages for model B discovery include hop\_count to indicate the number of hops from announcing UE (in model A) or the number of hops from discoverer UE (in model B). Each UE-to-UE Relay checks the hop\_count with the multi-hop authorization info which is associated with RSC to decide whether itself can perform as a multi-hop UE-to-UE Relay.

- When UE-to-UE Relay sends a Relay discovery message including direct discovery set received from End UE or from another UE-to-UE Relay, each direct discovery set is appended with hop count and user info of UE-to-UE relays in the path. The list of UE-to-UE Relays in the path is called "Route information".

- Each UE-to-UE Relay may include link quality information in the Relay discovery message (e.g. per hop delay or cumulative delay, etc.)

- When an End UE selects a multi-hop UE-to-UE Relay path to another End UE, it selects a multi-hop path based on several criteria (e.g. number of hops, channel quality, end to end delay, etc) and saves the Route information from the End UE to another End UE using UE-to-UE relays involved in the path.

- Multi-hop UE-to-UE Relay Connection setup

- After discovery procedure, End UE sends a DCR or a LMR to the first UE-to-UE Relay in the selected Route information to another End UE, including the Route information using UE-to-UE relays user info [list] in the path.

- When a UE-to-UE Relay receives a DCR or a LMR for end to end connection between source End UE and target End UE with Route information, the UE-to-UE Relay sends a DCR or LMR (when reusing existing PC5 connection) to another UE-to-UE Relay or target End UE at next hop based on the Route information.

- Support of multi-hop UE-to-UE Relay Connection setup with integrated discovery

- For integrated discovery, source End UE sends a DCR with relay\_indication. The relay\_indication is used to indicate whether UE-to-UE Relay can forward the Direct Communication Request message or not, and it is also used to limit the number of hops of by decreasing relay\_indication in the Direct Communication Request message from the UE-to-UE Relay. When a UE-to-UE Relay receives a DCR with relay\_indication, it sends a DCR for integrated discovery to another UE-to-UE Relay with appending user info ID of UE-to-UE Relay. Each UE-to-UE Relay may include link quality information in the DCR for integrated discovery to another UE-to-UE Relay (e.g. per hop delay or cumulative delay, etc.).

- For integrated discovery, when target End UE receives DCRs or LMRs for end to end connection setup with source End UE via multi-hop UE-to-UE Relays, it may select a proper multi-hop path to the source End UE based on several criteria (e.g. number of hops, channel quality, end to end delay, etc).

- The security is established between the target End UE and the first hop UE-to-UE Relay in the selected multi-hop path and sends DCA message (including the Routing information) to the first hop UE-to-UE Relay. The first hop UE-to-UE Relay establishes security with the next hop UE-to-UE Relay in the selected multi-hop path and sends DCA message (including the Routing information) to the next hop UE-to-UE Relay. This procedure is repeated until the source End UE is reached.

- After receiving QoS Info of the end-to-end QoS from source End UE, UE-to-UE Relay provides QoS Info of the reaming path to the next hop UE-to-UE Relay with LMR message. This procedure is repeated until the target End UE is reached.

- Multi-hop UE-to-UE Relay Reselection or path change

- Negotiated 5G ProSe UE-to-UE Relay reselection procedure is extended to multi-hop UE-to-UE Relay connection.

- When there is no UE-to-UE Relay available in single hop for relay reselection, source End UE sends a link modification request including a list of UE-to-UE relays available in multi-hop with indication of multi-hop extension.

- Target End UE may trigger Candidate Relay discovery procedure with multi-hop extension for the UE-to-UE Relay in the list of UE-to-UE relay from source End UE.

- Candidate Relay discovery procedures are extended to multi-hop by including indication of multi-hop connection and Route information of the path to the candidate Relay (i.e. list of UE-to-UE relays in the path).

- Target End UE selects new multi-hop UE-to-UE Relay path and sends the new multi-hop path to the source End UE.

- Supporting IP address/prefix allocation

- For multi-hop UE-to-UE Relay extension, each UE-to-UE Relay works as DHCP server.

- When UE is authorized as U2U relay UE and supporting DHCP server mechanism, the IP address pool is configured by NW to avoid collision between U2U relay UEs which behave as DHCP servers.

- For multi-hop UE-to-UE Relay extension with IP communication, an End UE is assigned an IP address from the UE-to-UE Relay after setting up a unicast PC5 link. UE-to-UE Relay stores an association of the User info of the UE of the unicast link and IP address/prefix allocated to the UE into its DNS entries. Each UE-to-UE Relay works as a DNS server for the UEs having PC5 connection with it.

- For IP routing between U2U relay UEs for multi-hop connection, during PC5 connection setup or during discovery, U2U relay UEs may share their range of IP address with other U2U relay UE.

- When a (source) UE needs to communicate with another (target) UE, it sends a DNS query for the target UE (based on Target User Info) and receives a DNS Response with the IP address/prefix of the target UE. UE-to-UE Relay may communicate with other UE-to-UE Relays to retrieve the IP address of the target UE.

### 6.6.2 Procedures

#### 6.6.2.1 5G ProSe multi-hop UE-to-UE Relay Discovery

##### 6.6.2.1.1 Multi-hop U2U Relay discovery using model A



Figure 6.6.2.1.1-1: Multi-hop U2U Relay Discovery with model A

Precondition: End UEs and U2U Relays are authorized and provisioned with multi-hop specific configurations, multi-hop authorization based on the capabilities/subscription, RSC supporting multi-hop U2U connection, and allowed max #hops per RSC.

1a. U2U Relay\_1 sends a U2U relay discovery announcement message including RSC, list of direct discovery set with assistance information (e.g, hop count for number of hops and cumulative delay information to the End UE in the discovery set, User info Relay\_1).

1b. U2U Relay\_2 sends a U2U relay discovery announcement message including direct discovery set received from U2U Relay\_1 with assistance information (e.g. hop count increased by 1 and updated cumulative delay, User info Relay\_1, and User Info Relay\_2).

2. U2U Relay\_3 sends a U2U relay discovery announcement message including direct discovery set of the End UEs in the proximity and direct discovery set received from other U2U relays. When including direct discovery set received from other U2U Relay, it updates its assistance information (e.g. hop count increased by 1 and updated cumulative delay, list of User Info of U2U Relays, User info of Relay\_3). For the direct discovery set of the End UEs in the proximity, the assistance information includes hop count set to zero.

When same direct discovery sets are received from different U2U Relays, U2U Relay\_3 selects a direct discovery set based on various criteria (e.g., minimum hop counter value, minimum cumulative delay, or channel quality of received message).

##### 6.6.2.1.2 Multi-hop U2U Relay discovery using model B



Figure 6.6.2.1.2-1: Multi-hop U2U Relay Discovery with model B

Precondition: End UEs and U2U Relays are authorized and provisioned with multi-hop specific configurations, multi-hop authorization based on the capabilities/subscription, RSC supporting multi-hop U2U connection, and allowed max #hops per RSC as specified in clause 6.6.1.

1a. End UE\_1 sends a U2U relay discovery solicitation message including , direct discovery set (user info of discoverer end UE, user info of discoveree end UE), RSC supporting multi-hop U2U connection, hop count value set to zero, .

1b. U2U Relay\_1 sends an U2U relay discovery solicitation message including , direct discovery set (user info of discoverer end UE, user info of discoveree end UE), RSC supporting multi-hop U2U connection, Routing information (i.e., user info of U2U relay\_1), hop count value increased by 1, , and delay information between End UE\_1 and U2U Relay\_1.

2. U2U Relay\_2 sends an U2U relay discovery solicitation message including , direct discovery set (user info of discoverer end UE, user info of discoveree end UE), RSC supporting multi-hop U2U connection, Routing information (i.e., user info of U2U relay\_1, user info of U2U relay\_2), hop count value increased by 1, , and cumulative delay information between End UE\_1 and U2U Relay\_2.

When hop count exceeds maximum number of hops allowed, or cumulative delay exceeds maximum delay allowed, the received discovery solicitation message is discarded.

If the same Direct Discovery Set is received from different U2U relays, U2U Relay\_2 may select a Direct Discovery Set to be sent to next hop based on various criteria (e.g., minimum hop counter value, minimum delay, or channel quality of received message).

3. Discoveree End UE (here End UE-2) sends an U2U Relay Discovery Response message when RSC matches the authorized information and Discoveree UE's user info matches its user info. U2U Relay Discovery Response message incudes RSC, direct discovery set (user info of discoverer end UE, user info of discoveree end UE), Route information of selected multi-hop path (i.e. list of U2U relays in the path), number of hops, and cumulative delays.

4. U2U Relay-2 sends a U2U Relay Discovery Response message to End UE-1 when receiving U2U Relay Discovery Response message from End UE-2. U2U Relay Discovery Response message includes RSC, direct discovery set (user info of discoverer end UE, user info of discoveree end UE), Route information of selected multi-hop path (i.e. list of U2U relays in the path), number of hops, and cumulative delays.

End UE-1 selects a multi-hop path to End UE-2 based on the information received in step 4.

#### 6.6.2.2 5G ProSe Communication via 5G ProSe multi-hop Layer-3 UE-to-UE Relay



Figure 6.6.2.2-1: IP address assignment procedure based on configured IP address pool for multi-hop relay

0. UE1 and UE2 are authorized for multi-hop UE-to-UE Relay service as End UE and are provisioned with parameters for discovery and connection setup with other UEs via multi-hop UE-to-UE Relay services.

U2U Relay\_1, and U2U Relay\_2 are authorized for multi-hop UE-to-UE Relay service as Relay UE and are provisioned with parameters for discovery and connection setup with other UEs and relay UEs via multi-hop UE-to-UE Relay services. The provisioned parameter may include parameters such as RSC (Relay service Code)(s), list of PLMN, User Info ID of UE for application which are allowed at multi-hop relay connection.

When U2U Relay\_1, and U2U Relay\_2 are authorized for multi-hop UE-to-UE Relay service as Relay UE, they are provisioned with IP address pool which can be used when relay UEs, as DHCP servers, assign IP address to the end UEs which have PC5 connection with relay UEs. It is to avoid the conflict of IP address at End UEs in multi-hop relay connection.

1. UE1 may perform multi-hop U2U relay discovery procedure to find end to end route to UE2 via multi-hop relay service as specified in 6.6.2.1 in this solution.

2. UE1 selects a proper multi-hop path with Route information (i.e. list of U2U Relay in the path) to UE2 based on the discovery result of step 1.

UE1 initiates a PC5 connection setup or modification procedure to the closest U2U relay in the selected path as specified in step 3 clause 6.7.1.1 of TS 23.304 [4]. Additionally, DCR or LMR includes Route information to indicate the selected multi-hop path. UE1 may send DCR to U2U Relay\_1 if UE1 has no PC5 connection with U2U Relay\_1 or UE1 may send Link modification request including selected e2e route to U2U Relay\_1 if UE1 has existing PC5 connection with U2U Relay\_1.

3. After sending DCR, security association procedure may be performed between UE1 and U2U Relay\_1.

4. After receiving DCR or LMR from UE1, U2U Relay 1 may trigger a new PC5 connection setup or modification of existing PC5 connection with entity at next hop in the selected multi-hop path. In DCR or LMR, Route information is included as received in step 3.

5. After sending DCR, security association procedure is performed between U2U Relay 1 and U2U Relay 2.

6. After receiving DCR or LMR from U2U Relay 1, U2U Relay 2 may trigger a new PC5 connection setup or modification of existing PC5 connection with entity at next hop in the selected multi-hop path (here UE2). In DCR or LMR, Route information included as received in step 4.

7. After sending DCR, security association procedure is performed between U2U Relay 2 and UE2.

8. UE2 sends DC Accept or LM accept to U2U Relay 2 when accepting the requested PC5 link setup or link modification for communication to UE1 via the selected multi-hop path.

9. For IP traffic, IPv6 prefix or IPv4 address is allocated for UE2 as defined in clause 5.5.1.4 of TS 23.304 [4]. When an IP address is assigned to UE2, the IP address value shall be within the IP address pool configured at U2U Relay 2 during step 0. U2U Relay2 stores an association of User Info ID and assigned IP address of UE2 for use DNS lookup and IP traffic routing. U2U Relay 2 may act as a DNS server to End UEs and Relay UEs having PC5 connection with Relay 2.

10. U2U Relay 2 sends DC Accept or LM accept to U2U Relay 1 after receiving DC accept or LM accept from UE2.

During PC5 connection setup or link modification procedure between U2U Relay 1 and U2U Relay 2, each Relay UE's assigned IP address pool may be shared to each other so that U2U relay 1 and U2U relay 2 are aware of other relay UE's IP address pool. Other U2U relay UE's IP address pool information may be used for IP traffic forwarding to correct relay UE when receiving IP data from End UE to forward other end UE in multi-hop relay connection.

11. U2U Relay 1 sends DC Accept or LM Accept to UE1 after receiving DC Accept or LM Accept from Relay 2.

U2U Relay1 saves mapping information between User Info of UE2 and U2U Relay2 which have a PC5 link with UE2.

12. For IP traffic, IPv6 prefix or IPv4 address is allocated for UE1 as defined in clause 5.5.1.4 of TS 23.304 [4]. When an IP address is assigned to UE1, the IP address value shall be within the IP address pool configured at U2U Relay 1 during step 0. U2U Relay1 stores an association of User Info ID and assigned IP address of UE1 for use DNS lookup and IP traffic routing. U2U Relay 1 may act as a DNS server to End UEs and Relay UEs having PC5 connection with Relay 1.

13. UE1 may send a DNS query including user info ID of UE2 to U2U Relay 1 to request IP address of UE2.

14. U2U Relay 1 decides to send DNS query to relay 2 based on the mapping between user info of UE2 and relay2. And U2U Relay 1 may communicate with U2U Relay 2 to retrieve an IP address of UE2 using User Info ID of UE2.

15. U2U Relay 1 sends a DNS response including IP address of UE2 to UE1.

16. Based on received IP address of UE2, UE1 may exchange IP traffic with UE2 via multi-hop path. When receiving IP packet between UE1 and UE2, U2U relay 1 and U2U relay2 forward IP packet to U2U relay 2 and U2U relay 1 based on information of IP address pool handled by relay UE.

#### 6.6.2.3 5G ProSe multi-hop Layer-3 UE-to-UE Relay Reselection with negotiated U2U relay reselection procedure

This solution is about negotiated layer-3 UE-to-UE relay reselection procedure with multihop relay discovery support and with list of candidates U2U relays which are directly reachable by Initiating End UE(UE1).

Based on the list of U2U relays, Responding End UE(UE2) tries to find new end to end route to UE1. UE2 may consider multi-hop routes to UE1 if there is no relay in the provided list reachable directly by UE2.

Once UE2 determines that multi-hop connection is needed (e.g. because no candidate relays are directly reachable), UE2 initiates multi-hop U2U relay discovery for UE1 or multi-hop candidate U2U relay discovery for relay UEs in the list, if needed.

UE2 selects an end-to-end route to reach UE1 based on received information from the discovery procedure, initiates PC5 connection setup procedure via this selected route and informs UE1 about the selected e2e route.

During this negotiated U2U Relay reselection procedure, UE1 and UE2 exchange their new IP address to be used at the newly selected end to end route.



Figure 6.6.2.3-1: Layer3 based Negotiated UE-to-UE Relay reselection procedure

0. UE1, UE2 are authorized for multi-hop U2U Relay service as End UE and are provisioned with parameters for discovery and connection setup with other UEs via multi-hop UE-to-UE Relay services.

Relay1, Relay2, Relay3, and Relay4 are authorized for multi-hop U2U Relay service as Relay UE and are provisioned with parameters for discovery and connection setup with other UEs and relay UEs via multi-hop UE-to-UE Relay services.

1. UE1 and UE2 setup PC5 connection with Relay1 for communication between UE1 and UE2.

2. UE1 and UE2 exchange data traffic e.g., IP traffic, via Relay1.

3. UE1 (initiating End UE) determines, e.g. based on PC5 signal strength, to perform U2U Relay reselection.

UE1 obtains a list of U2U Relays which are accessible by UE1 in direct PC5 connection and support multi-hop connection (e.g. via U2U Relay Discovery Procedure). The list of UE-to-UE Relays may include the U2U Relays which have PC5 connection with UE1.

4. UE1 sends a Link Modification Request message to relay1. Link Modification Request includes a Relay re-selection indication, information of candidate UE-to-UE Relay(s), IP addresses of the responding End UEs (here UE2), IP address of UE1, and indication of multi-hop connection supported.

5. Based on received End UEs IP address in step 4, Relay1 determines the responding End UEs (here UE2) and sends a Link Modification Request message to the responding End UEs (here UE2).

The Link Modification Request message includes a Relay re-selection indication, User Info ID(s) of the candidate UE-to-UE Relay(s), IP address of UE1, and indication of multi-hop connection supported.

6. After receiving Link Modification Request for Relay reselection with list of U2U Relays, for each U2U relay, UE2 may perform multi-hop candidate Relay discovery procedure to find available multi-hop path to each candidate U2U Relay with number of hop and delay.

7. UE2 may select a proper multi-hop path to UE1 based on discovery results at step 6 (e.g., link quality, number of hops of e2e route, end to end delay of e2e route, etc.)

8. UE2 may initiate PC5 connection setup or modification procedure for communication with UE1 with Routing information for the selected multi-hop path as shown in clause 6.6.2.2 in this solution.

9. UE2 sends a Link Modification Accept message to Relay1. Link Modification Accept message includes Route information for the new multi-hop path, IP address of UE1, IP address of UE2, new IP address of UE2 at newly selected multi-hop path, and Relay re-selection indication.

10. Relay1 sends Link Modification Accept message to UE1. The Link Modification Accept message includes Route information for the new multi-hop path, IP address of UE1, IP address of UE2, new IP address of UE2 at newly selected multi-hop path, and Relay re-selection indication.

11. UE1 sends Link Modification Ack to relay1. Link Modification Ack includes the IP address of UE1 at newly selected multi-hop path, IP address of UE2 and Relay reselection indication.

12. Relay1 sends Link Modification Ack to UE2. Link Modification Ack includes the IP address of UE1 at newly selected multi-hop path, IP address of UE1, IP address of UE2 and Relay reselection indication.

13. UE1 and UE2 transfer traffic via the newly selected multi-hop path.

6.6.2.4 5G ProSe Multi-hop UE-to-UE Relay QoS Handling



Figure 6.6.2.4-1: QoS control for Layer 3 UE-to-UE Relay

1. When the Source End UE initiates unicast communication establishment with the target End UE, it decides the E2E QoS parameters between Source End UE and Target End UE based on the application layer requirements. The Source End UE sets up a PC5 QoS Flow. Then Source End UE provides the E2E QoS parameters to a U2U Relay in a DCR message, corresponding to step 2 in Figure 6.5.2.3-1.

2-3. The U2U Relays decide the PC5 QoS hop by hop. i.e., the U2U Relay splits the QoS parameters, according to the received QoS Info, into two parts: one part is the QoS parameters of the previous hop, the other part is the QoS parameters from the U2U Relay to Target End UE (the rest PC5 QoS parameters). The U2U Relay sends the rest QoS parameters to the next hop.

4. Target End UE sends the accepted PC5 QoS with a U2U Relay in a DCA message, corresponding to step 8 in Figure 6.6.2.3-1.

5-6. For each U2U Relay, if the previously received “the rest PC5 QoS parameters” can be satisfied according to the accepted PC5 QoS in the received DCA message, U2U Relay sends the accepted PC5 QoS with the previous hop in a DCA message.When the QoS flow is applied to an existing PC5 link between the End UE and the U2U relay, or between two U2U relays, Link modification procedure is applied with the same principle.

### 6.6.3 Impacts on services, entities and interfaces

5GC:

- Authorization and provisioning parameters for multi-hop Layer-3 UE-to-UE Relay

End UE, U2U Relay:

- Support Multi-hop Layer-3 UE-to-UE Relay functionality

\* \* \* End of change \* \* \*