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**Title:** **KI #3: New Sol:** **IMS solution in UE-Sat-UE deployment**

**Document for:** **Approval**

**Agenda Item: 19.1**

**Work Item / Release:** **FS\_5GSAT\_ARCH\_Ph3 / Rel-19**

Abstract of the contribution: The contribution proposes a solution to KI#3: Support of UE-satellite-UE communication.

# Introduction

This contribution proposes IMS architecture and procedure enhancement to support UE-Sat-UE deployment.

# Discussion

The proposed solution is considering the below listed challenges in UE-Sat-UE scenario in NTN.

- How to ensure routing of user plane traffic remains in the satellite.

- Potential impacts on IMS procedures and functions to manage UE-satellite-UE communication.

- Minimize service interruption if the Serving Satellite changes.

Solutions brief:

1. The solution proposes to move the IMS U-plane entity routing onboard the satellite to avoid the delay caused by the longer distance between the regenerative RAN onboard satellite and U-plane functions at the ground.
2. The solution proposes to keep the IMS PDU contact address anchored to ground UPF. This helps in avoiding frequent re-REGISTER when there is frequent satellite change.
3. For U-plane offloading onboard satellite, it is proposed to insert I-UPF onboard satellite and provision appropriate filter rules for U-plane traffic routing.
4. The solution solves how to identify if the called and calling party are under satellite access to enable UE-Sat-UE communication.

# Proposal

A solution is proposed for KI#3 for incorporation in the FS\_5GSAT\_ARCH\_Ph3 TR23.700-29.

\*\*\* Start of changes (all new text) \*\*\*

## 6.X Solution #X: UE-Sat-UE communication using resource allocation on-board satellite.

### 6.X.1 Key Issue mapping

This solution aims to resolve Key Issue #3, " Support of UE-satellite-UE communication".

### 6.X.2 Description

This solution aims to ensure that the routing of user plane traffic for IMS (MMTEL) remains in the satellite(s) when both parties are served by a satellite of the same constellation. It considers that both parties could be served by the same or different satellites involving same or different SMF, UPF, PCF, P-CSCF.

This solution considers potential impacts on IMS procedures and functions to manage UE-satellite-UE communication, trying to minimize these IMS impacts: for this purpose, the solution assumes all the IMS subsystems remain on the ground with the possible exception of IMS-AGW that may be deployed on satellite that serve jurisdictions where LI may apply (See clause 6.X.3.5).



**Figure 6.X.2‑1 UE-Sat-UE IMS user plane offload**

NOTE 1: The C-plane line shows the entities which may be involved in signalling, not necessarily the exact signaling path. The IBCF is not used when calling and the called party correspond to the same IMS Home network.

This solution is based on the following principles:

* For the IMS related PDU Session, UE(s) get an IP address from a PSA UPF located on the ground. Thus, their IP address is not changed when they change satellite.
* UE(s) register onto IMS with this IP address.

NOTE 2: Thus UE(s) keep their IP address constant and don’t need to reregister when there is change of serving satellite.

* Upon UE registration, the P-CSCF may subscribe to the PCF for the UE connectivity via satellite constellation: at subscription, it gets notified (whether/that) the UE is served by which satellite constellation and then gets notified when the serving satellite constellation changes for the UE.

This assumes that the AMF notifies the SMF (that notifies the PCF) about whether a UE is served by a given satellite constellation and that such notifications are also sent when the UE changes satellite constellation.

* The solution assumes, ISL(s) can be set-up within the same satellite constellation or across different constellations depending on satellite operator’s deployments (SLA). The set of ISL(s) build up an IP network which is outside of the scope of 3GPP.
* The fact that a UE is served by a satellite of a constellation may be carried in a (e.g PANI P-Access-Network-Info defined in clause 4.4 of RFC 3455) SIP header that is sent (for an IMS call) between the originating and the terminating party’s P-CSCF but shall never be sent to the other UE. For example, this information will be added by the originating P-CSCF and removed by the terminating P-CSCF at the border of the trust domain.
* Based on SIP header information (e.g. PANI) associated with the remote party of a call and on the information received from the PCF for the local UE, a P-CSCF may detect that both parties of a call are served by the same satellite constellation or served by satellite constellation that supports inter constellation ISL (N6 termination towards each other). This applies for both originating and terminating P-CSCF. In this case, P-CSCF will not anchor the media in an IMS-AGW.

NOTE 3: The PANI header is not changed in this proposal. The P-CSCF uses both PANI and PCF notified access information to determine the possibility of UE-Sat-UE call.

* An ISL IP network using ISL links is used for UE-Sat-UE user plane communication where UPF (I-UPF) onboard satellite can route U-plane packets to other user’s satellite’s UPF (I-UPF). PtP tunnelling can be applicable for I-UPF to I-UPF packet forwarding where the media flows with inner source/destination IP address of both UE(s) are sent in an IP over IP tunnel where the outer source/destination IP addresses correspond to the I-UPF(s) serving each of the UE(s). It is assumed that inter I-UPF in satellite data traffic use a dedicated PtP tunnel over ISL IP network.
* NOTE 4: The PtP tunnelling mechanism follows the same concept as described in clause 9.2 in TS 29.561. The PtP tunnel information can be preconfigured per ISL communication path. The Satellite identification can be mapped to each PtP tunnel endpoint to enable I-UPF (UL-CL) to select the N6 forwarding endpoint based on the other party’s satellite access (i.e. PtP tunnel endpoint pointing to other UEs N6 endpoint). As described in clause 9.3 in TS 29.561 and clause 4.3.17.8.3.3.3 of 3GPP TS 23.401, the PtP tunnelling setup via other mechanism such as GRE/PMIP, L2TP are not precluded in this solution proposal. if the PtP tunnel information is not configured against the ISL where other UE is present, then the call setup needs to be done via ground network and I-UPF allocation is no needed. This check against the presence of PtP towards the other’s UE satellite is done also during HO procedure to make sure, call continuity is maintained, if not the call reestablishment via ground network needs to be carried out. The PtP tunnel can be per Sat-Sat pair and there can be multiple PtP tunnel between 2 satellite and it is up to the UPF to choose which PtP tunnel to use.

The description below applies for the P-CSCF / PCF / SMF at the first side of an IMS call where QoS resources are reserved:

NOTE 5: this corresponds for example, to the procedure in clause 6.X.3.2.

1. When the P-CSCF invokes PCF services to request Authorization of QoS resources and to fetch the user location (ANI) from the access network (as defined in TS 23.228 e.g. step 6b of Figure R.3-1, step 5 of Figure R.4-1), the P-CSCF may ask to insert a local N6 breakout point for the corresponding QoS resources and to report addressing information for this local N6 breakout point.

NOTE 6: This is done using Rx/N5 services and not Nnef Traffic Influence API. Using Nnef Traffic Influence API would be possible but would require more API invocation between P-CSCF (acting as an AF) and the PCF which in turn would have induced more N7 and N4 signalling. This would increase the call set-up delay.

1. The PCF via PCC rules, transfers the request to the SMF; the SMF:

b1) (based on the PCF request to ask to insert a local N6 breakout point) allocates for the Session (a) I-UPF(s) on the satellite currently serving the UE and configures the UPF(s) to act as UL CL (to break out only traffic corresponding to the SDF indicated by the PCF) and/or as L-PSA (local N6 breakout point); it retrieves from the L-PSA UPF the local (outer IP) addressing information corresponding to the local N6 breakout point;

b2) requests QoS resources and location information from the RAN;

b3) reports to the PCF ANI that contains both the location information received from the RAN and (outer IP) address information corresponding to the local N6 breakout point (and retrieved from the L-PSA).

1. The PCF reports the information provided by the SMF to the P-CSCF that ensures that the (outer IP) addressing information corresponding to the local N6 breakout point is transferred via SIP header information (e.g. PANI) or via SDP to the P-CSCF handling the other party.
2. When the P-CSCF receives (outer IP) addressing information corresponding to the N6 breakout point of the other party it transfers the information to the PCF that updates the corresponding PCC rule to the SMF. The SMF updates the PSA UPF with the received (outer IP) addressing information to be used for UL media traffic to be sent on the ISL IP network.

The description below applies for the P-CSCF / PCF / SMF at the second side of the call where QoS resources are reserved. The description for the first side of the call where QoS resources are reserved above applies to the other side / party of the call where QoS resources are reserved with the following modification:

* If Step a) and Step d) take place at the same time, the P-CSCF, having received remote (outer IP) addressing information from the remote party before it has requested Authorization of QoS resources, can at the same time request local traffic switching and provide remote (outer IP) addressing information.
* this corresponds to the procedure in clause 6.X.3.3

### 6.X.3 Procedures

#### 6.X.3.1 Overview

The call flows of clause 6.X.3.2 describe the case of an SDP Offer-answer scenario where resources are first reserved when the SDP Answer is processed by the local P-CSCF and then resources are reserved at the side of the SDP offer.

#### 6.X.3.2 PCC and SMF Procedures for IMS Session Establishment at terminating P-CSCF and PCF

This clause details the changes to be made to TS 29.513 Annex B.2.2. it uses the same step numbers.



Figure 6.X.3.2-1: PCC Procedures for IMS Session Establishment at terminating P-CSCF and PCF

0. at IMS initial registration onto the P-CSCF the P-CSCF subscribes (Npcf\_PolicyAuthorization\_Subscribe targeting the UE IP address in the contact header) onto the PCF about (Event = [Access Network Information Reporting-> “Current Satellite Constellation ID”]) the UE connectivity via satellite connection: at subscription time (via immediate reporting) it gets notified (whether/that) the UE has changed the satellite constellation (Npcf\_PolicyAuthorization\_Notify). The P-CSCF stores the association between the UE and a satellite constellation.

1. The P-CSCF receives the SDP parameters defined by the originator together with the originated side IMS core generated SIP header (e.g. PANI), indicating that the originator is served by a satellite of a given constellation (Satellite ID+ Satellite constellation ID). The following assumes both UEs involved in the call are served by the same satellite constellation or satellites across constellation having ISL (detected based on a match between the remote UE information received in the SIP header (e.g. PANI) and the local UE information retrieved at step 0)

2. The P-CSCF identifies the connection information needed (IP address of the up-link IP flow(s), port numbers to be used, etc.).

3. The P-CSCF sends the SDP offer to the UE (removing any SIP header info (e.g. PANI) received from the other party).

4. The P-CSCF receives the negotiated SDP parameters from the UE.

5. The P-CSCF identifies the connection information needed (IP address of the downlink IP flow(s), port numbers to be used, etc.) to request resource reservation.

6. The P-CSCF invokes the Npcf\_PolicyAuthorization\_Create service operation to forward the derived service information to the PCF.

6a. (if Rx applies instead of N5) The P-CSCF forwards the derived service information to the PCF by sending a Diameter AAR for a new Rx Diameter session.

In both cases (6. and 6a), the P-CSCF uses the same request to also fetch the local user location (Access Network Information ANI) and/or UE Time Zone information from the access network (as defined in TS 23.228 e.g. step 6b of Figure R.3-1, step 5 of Figure R.4-1), and asks to insert a local N6 breakout point for the corresponding QoS resources and to report addressing information for this local N6 breakout point.

If the P-CSCF assigned IMS-AGW resources before in the context of step 2, it releases the resources.

7. The PCF stores the received session information and performs Session binding. For the N5 interface, the PCF creates an "Individual Application Session Context" resource to store the received application session information.

8. The PCF sends a [an HTTP "201 Created"] Npcf\_PolicyAuthorization\_Create response to the P-CSCF [and includes the URI of the "Individual Application Session Context" resource in the Location header field. (8a.) In case 6a applies The PCF sends a Diameter AAA to the P-CSCF].

9. If the P-CSCF did not request “access network information” in step 6 (or step 6a for the Rx case), upon reception of the acknowledgement from the PCF, the SDP parameters in the SDP answer are passed to the originator.

10. The PCF executes interactions according to clause 5.2.2.2.1 in TS 29.513. This step implies provisions related PCC rules corresponding to the information received in step 6/6a. This is executed in parallel with steps 8 (or step 8a for the Rx case) and 9.

Upon reception of the PCC rules the SMF:

b1) (based on the PCF request to insert a local N6 breakout point) allocates for the PDU Session (a) (an) I-UPF(s) on the satellite currently serving the UE and configures the UPF(s) to act as UL CL (to break out only U-plane traffic corresponding to the SDF indicated by the PCF) and/or as L-PSA (local N6 breakout point); the SMF creates a PDR/FAR referring to the network of ISL(inter-satellite links) and the UPF answers back with addressing information corresponding to the local N6 breakout point (termination point at the L-PSA of the N6 tunnel over the ISL network)

b2) requests QoS resources and ANI (Access Network Information) from the RAN

b3) reports ANI to the PCF that contains both the information received from the RAN and address information corresponding to the local N6 breakout point (termination point at the L-PSA of the N6 tunnel over the ISL network).

NOTE 1: The N6 termination point routing/next hop information is provided by PCF based on satellite ID/Satellite constellation ID.

NOTE 2: If the N6 termination information cannot be determined at this time, the PCF shall wait for step 14 to receive the same from the originating side once the originating side setups up its own U-plane resources.

11. If the P-CSCF requested access network information and/or EPS fallback indication in step 6, the PCF invokes the Npcf\_PolicyAuthorization\_Notify service operation to forward EPS fallback indication, if received in step 10, and/or the ANI received in step 10 [by sending an HTTP POST request to the Notification URI received in step 6].

11a. Rx equivalent of the N5 procedure described in step 11.

12. If step 11 occurs, the P-CSCF acknowledges the receipt of the notification request with an [HTTP "204 No Content"] Npcf\_PolicyAuthorization\_Notify response.

12a. If step 11a occurs, the P-CSCF acknowledges the receipt of Diameter RAR.

13. If step 11 occurs (or step 11a for the Rx case), the P-CSCF forwards the SDP answer and includes the network-provided location information (ANI) in the next SIP message the P-CSCF sends towards the IMS core network.

 As a difference with R18 behaviour, the IMS Core of the local UE ensures that information corresponding to the local N6 breakout point is transferred via the SIP header (e.g. PANI) towards the P-CSCF handling the other party (here originator of the call).

14. The terminating P-CSCF receives addressing information corresponding to the remote outer tunnel N6 breakout point transferred via SIP header (e.g. PANI) (and ensures this information is not sent to the UE). This step can correspond to SIP UPDATE and SIP 200 OK (UPDATE) carrying remote end information.

15. The P-CSCF provides (via PCF) the SMF with addressing information corresponding to the remote outer tunnel N6 breakout point. This information is sent to the SMF via traffic steering information in a PCC rule (refer to clause 6.3.1 in TS 23.503 for “Application Function influence on traffic routing Enforcement Control”)

16. the SMF Sends a corresponding N4 PDR/FAR to the UPF in such a way that media from the local UE to the remote UE is sent by the local PSA (I-UPF) (inserted in step 10 b1) in a tunnel whose destination address corresponds to the addressing information of the remote outer tunnel N6 breakout point: the SMF updates the corresponding FAR/Forwarding Parameters / Outer Header Creation accordingly.

 If the addressing information of the remote outer tunnel N6 breakout point corresponds to the local PSA (i.e. if both the UEs are served by the same satellite), then local traffic switching at the L-PSA I-UPF needs to take place.

NOTE 3: The local switching can be done by UPF based on its internal mechanism or by keeping a dedicated PtP tunnel for loopback routing.

#### 6.X.3.3 PCC and SMF Procedures for IMS Session Establishment at Originating P-CSCF and PCF

This clause details the changes to be made to TS 29.513 Annex B.2.1. it uses the same steps numbers.



Figure 6.X.3.3-1: PCC Procedures for IMS Session Establishment at originating P-CSCF and PCF

1. The P-CSCF receives the SDP parameters defined by the originator within an SDP offer in SIP signalling.

2. The P-CSCF identifies the connection information needed (IP address of the down link IP flow(s), port numbers to be used, etc.).

3. The P-CSCF forwards the SDP offer in SIP signalling.

4. The P-CSCF gets the negotiated SDP parameters from the terminating side through SIP signalling interaction together with terminating side IMS core generated SIP header (e.g. PANI) indicating that the terminating side is served by a satellite of a given constellation (Satellite constellation ID) and/or I-UPF’s local termination information. (This corresponds to Step13 in Figure 6.X.3.2-1 from terminating side)

5. The P-CSCF identifies the connection information needed (IP address of the up-link media IP flow(s), port numbers to be used, etc.).

6. The P-CSCF invokes the Npcf\_PolicyAuthorization\_Create service operation to forward the derived session information to the PCF by sending an HTTP POST request to the "Application Sessions" resource.

6a. The P-CSCF provides session information to the PCF by sending a Diameter AAR for a new Rx Diameter session.

7. The PCF stores application session information and performs session binding. For N5 interface, the PCF creates an "Individual Application Session Context" resource to store the received application session information.

8. The PCF replies to the P-CSCF with a HTTP "201 Created" response and includes the URI of the "Individual Application Session Context" resource in the Location header field.

8a. The PCF sends a Diameter AAA to the P-CSCF.

9. Upon reception of the acknowledgement from the PCF, the SDP parameters are passed to the UE in SIP signalling.

10. The PCF executes interactions according to figure 5.2.2.2-1 in TS 29.513. This step implies provisioning of PCC rules and is executed in parallel with steps 8 and 9 (steps 8a and 9a for Rx case).

Upon reception of the PCC rules the SMF:

b1) (based on the PCF request to insert a local N6 breakout point) allocates for the PDU Session (a) (an) I-UPF(s) on the satellite currently serving the UE and configures the UPF(s) to act as UL CL (to break out only U-plane traffic corresponding to the SDF indicated by the PCF) and/or as L-PSA (local N6 breakout point); the SMF creates a PDR/FAR referring to the network of ISL(inter satellite links) and the I-UPF answers back with addressing information corresponding to the local N6 breakout point (termination point at the L-PSA of the N6 tunnel over the ISL network of the terminating side)

b2) requests QoS resources and ANI (Access Network Information) from the RAN

b3) reports ANI to the PCF that contains both the information received from the RAN and addressing information corresponding to the local N6 breakout point (termination point at the L-PSA of the local outer tunnel N6 tunnel over the ISL network).

11. If the P-CSCF requested ANI and/or EPS fallback indication in step 6, the PCF invokes the Npcf\_PolicyAuthorization\_Notify service operation to forward the EPS fallback indication, if received in step 10, and/or the ANI received in step 10 in an HTTP POST request sent to the Notification URI received in step 6.

11a. If the P-CSCF requested ANI and/or EPS fallback indication in step 6a, the PCF forwards the EPS fallback indication, if received in step 10, and the ANI received in step 10 in a Diameter RAR.

12. If step 11 occurs, the P-CSCF acknowledges the receipt of the notification request with an [HTTP "204 No Content"] Npcf\_PolicyAuthorization\_Notify response to the PCF.

12a. If step 11a occurs, the P-CSCF acknowledges the receipt of Diameter RAR.

13. If step 11 occurs (step 11a for Rx case), the P-CSCF forwards the network provided location information in a subsequent SIP message to IMS core network together a SIP header (e.g. PANI) indicating that the terminating side is served by a satellite of a given constellation (Satellite constellation ID) and/or PSA I-UPF’s local outer tunnel N6 breakout point information. The P-CSCF, based on local configuration, may also include the EPS fallback indication, if received. (This step corresponds to step 14 in clause 6.X.3.2)

#### 6.X.3.4 Change of Satellite in UE-Sat-UE scenario (mobility)



**Figure 6.X.3.41 Change of Satellite in UE-Sat-UE**



**Figure 6.X.3.42 Change of Satellite using simultaneous change of UL CL**

The above call flow is based on clause 4.3.6.7 from TS 23.502.

UE has an established PDU Session with a UPF, including the PDU Session Anchor (Ground UPF). The PDU Session user plane involves at least the Source (R)AN, Source UL CL and the ground UPF (PDU Session Anchor, PSA), where Source UL CL and the terminating side are communicating over PtP tunnel.

1. SMF decides to change the UL CL due to UE mobility (change of satellite).
2. The SMF selects a UPF and using N4 establishes the Target UL CL for the PDU Session. SMF provides the necessary (for SIP signalling) uplink forwarding rule towards the PSA, including the tunnel info for the ground UPF. If session continuity upon UL CL relocation is used, the SMF also uses N4 to establish an N9 forwarding tunnel between the Source UL CL and Target UL CL, including the Tunnel Info for each UPF. In addition, the AN Tunnel Info to target (R)AN is provided for downlink forwarding to the target UL CL. In the case of UL CL, the SMF provides traffic filters indicating what traffic shall be forwarded towards PSA and Source UL CL, respectively. The target UL CL is configured with UL PDR/FAR to point to source UL CL and the source UL CL is configured with DL PDR/FAR to point to target UL CL. The SMF also fetches the N6 endpoint information from the target UL CL and informs P-CSCF via PCF (as described in clause 6.X.3.3 step 10-12)

NOTE 1: When session continuity upon UL CL relocation is used, the downlink traffic at this point goes through Source UL CL, Target UL CL and Target (R)AN.

1. The SMF updates the PSA via N4. It provides the PDU Session CN Tunnel Info for the downlink traffic. The Ground UPF now points to target UL-CL (for SIP signalling).
2. The SMF updates (R)AN via N2 SM information over N11. It provides the new CN Tunnel Info corresponding to the Target UL CL.

NOTE 2: When session continuity upon UL CL relocation is used, the uplink traffic destined to Source AGW-NT at this point goes through Target (R)AN, Target UL CL and Source UL CL and then to Source AGW-NT.

5. When the P-CSCF receives the reinvite with new P-ANI header due to a change of satellite and sends the reinvite along with an additional header as described in step 13 of Figure 6.X.3.3-1 and receives the 200 OK along with terminating side N6 endpoint information. The P-CSCF shall send policy\_authorization update by including the new PCC rules based on terminating side N6 information to PCF. PCF shall send the PCC rule update to SMF. SMF configures the target UL-CL with the filter rules and forwarding rules to point to new N6 of the terminating side. The target UL-CL will then continue to forward the packets belonging to source N6 terminating PtP via source UL-CL (N9), and now start forwarding the packet belonging to target N6 terminating PtP via N6.

6. When session continuity upon UL CL relocation is used, detection of no active traffic over the N9 forwarding tunnel is performed during a time interval provisioned by SMF for User Plane inactivity report in order to release the N9 forwarding tunnel. The detection can be done by Source UL CL, which notifies the SMF of no active traffic over the N9 forwarding tunnel. The SMF releases the Source Branching Point or the Source UL CL.

NOTE 3: It is up to network configuration whether the detection of no active traffic is performed by the Source UL CL or the Target UL CL. As an alternative to the detection of no active traffic, the P-CSCF can send an explicit notification (traffic influence) to the SMF when traffic to/from this UE ceases to exist, leading the SMF to release the Source UL CL. The notification can be sent after step 29 in the above diagram.

#### 6.X.3.4 Roaming case in UE-Sat-UE scenario



**Figure 6.X.3.4-1: Voice roaming architecture using LBO**

* For IMS roaming to work, the P-CSCF and S-CSCF exchange and record each other’s Uniform Resource Identifiers (URIs) during IMS registration as specified in 3GPP TS 24.229. The recorded S-CSCF URI is added as an SIP route header during the session setup by P-CSCF to route the originated sessions to the S-CSCF, and similarly, the S-CSCF adds the recorded P-CSCF URI as a SIP route header to route terminated sessions to the P-CSCF as specified in 3GPP TS 24.229.
* The rest of the procedure will remain the same as described in clause 6.X.3.2 and 6.X.3.3. The IPX network performs routing based exclusively upon the topmost SIP Route header that must contain the address of the destination network.

#### 6.X.3.5 Support for jurisdictions where LI can apply

When the satellite serves an area where LI may apply, the architecture supports an IMS-AGW on board of the satellite, as depicted in Figure 6.X.3.5-1.

This figure depicts a change of satellite at the side of the left UE where S-RAN / S-I-UPF and S-AGW-NT represent the RAN, the intermediate UPF (supporting both a UL CL and a local PSA) and the IMS AGW on the source (initial) satellite serving the UE;

The routing between AGW-NTs across satellite via ISL is assumed to be based on IP routing and the AGWs in satellite needs to have non-conflicting IP address during resource allocation. It is up to the deployment to manage IP routing across ISL links.



Figure 6.X.3.5-1: AGW resource allocation in satellite



**Figure 6.X.3.5-2: P-CSCF and IMS-AGW interaction**

The call flow follows clause 6.2.1, Gate Control & Local NA(P)T procedure in TS 23.334. The IMS-AGW is replaced by IMS-AGW-NT. In the above figure, the AGW-NT1 is the source AGW-NT, and AGW-NT2 is the target AGW-NT, as represented in Figure 6.X.3.5-1.

Upon receipt of a session initiation request, the IMS-ALG shall extract the offeror’s destination network address(es) and port number(s) from the signalling message body received from the calling party endpoint. It shall then request the IMS-AGW-NT1 to allocate transport resources (T2) via the Reserve AGW Connection Point procedure. Upon receipt of the response from the IMS-AGW-NT1, the IMS-ALG shall modify the offeror’s destination address(es) and/or port(s) contained in the application signalling message body and propagate the session establishment toward the terminating party.

On receipt of the terminating end SDP in the session establishment response, the IMS-ALG shall pass the information to the IMS-AGW-NT1 in the Configure AGW Connection Point procedure and shall request the IMS-AGW-NT1 to allocate transport resources (T1) via the Reserve and Configure AGW Connection Point. Upon receiving the response from the IMS-AGW-NT1, the IMS-ALG shall modify the answerer's destination address(es) and/or port(s) contained in the application signalling message body and pass the information to the originating party.

On session termination, the IMS-ALG shall request the IMS-AGW-NT1 to release its transport resources via the Release AGW Termination procedure.

1. Upon receipt of a session initiation request, the P-CSCF(IMS-ALG) shall extract the offeror’s destination network address(es) and port number(s) from the signalling message body received from the calling party endpoint.
2. It shall then request the IMS-AGW-NT1 to allocate transport resources (T2) via the Reserve AGW Connection Point procedure. The request optionally can include local endpoint information to identify which PtP tunnel to use for forwarding user plane traffic to the terminating end.
3. AGW-NT1 reserve resources (T2)
4. Once AGW-NT1 reserves resources (T2), it shall indicate the reserved resources to P-CSCF and optionally the local user plane traffic endpoint PtP tunnel information (IP and Port).
5. Upon receipt of the response from the IMS-AGW-NT1, the P-CSCF(IMS-ALG) shall modify the offeror’s destination address(es) and/or port(s) contained in the application signalling message body.
6. P-CSCF propagate the session establishment toward the terminating party. It shall also include an additional SIP header (e.g., a P-ANI header) to indicate its satellite access information, such as satellite ID and optional local tunnel endpoint info.
7. P-CSCF receives the terminating end SDP with an additional SIP header containing information about terminating point satellite access (e.g. P-ANI header) indicating its satellite access information, such as satellite ID and optionally remote tunnel endpoint info.
8. On receipt of the terminating end SDP in the session establishment response, the P-CSCF(IMS-ALG) shall pass the information to the IMS-AGW-NT1 in the Configure AGW Connection Point procedure and shall request the IMS-AGW-T to configure transport resources (T2) via the Configure AGW Connection Point. It can optionally include the terminating point satellite access information (remote tunnel endpoint info).
9. AGW-NT1 shall configure the terminating side transport endpoint (T2).
10. AGW-T sends ack for T2 configuration complete.
11. The P-CSCF(IMS-ALG) shall pass the information (originating side) to the IMS-AGW-NT1 in the Configure AGW Connection Point procedure and shall request the IMS-AGW-NT1 to allocate transport resources (T1) via the Reserve and Configure AGW Connection Point.
12. AGW-NT1 reserve resources for T1.
13. Once the AGW-NT1 configures itself (T1), it acknowledges to P-CSCF.
14. Based on the T1 resource reservation, P-CSCF modifies the SDP.
15. P-CSCF sends modified SDP answer to the originating side UE.

NOTE: The mobility procedure in 5GS is explained in figure 6.X.3.5-3.

1. Due to change of satellite (mobility), the UE shall send re-invite with new P-ANI header indicating new satellite information. The P-CSCF shall determine the new AGW based on satellite information received in P-ANI header.
2. P-CSCF shall then request the IMS-AGW-NT2 to allocate transport resources (T2) via the Reserve AGW Connection Point procedure. The request optionally can include local endpoint information to identify which PtP tunnel to use for forwarding user plane traffic to terminating end.
3. AGW-NT2 reserve resources (T2).
4. Once AGW-NT2 reserves resources (T2), it shall indicate the reserved resources to P-CSCF and optionally the local user plane traffic end point PtP tunnel information (IP and Port).
5. Upon receipt of the response from the IMS-AGW-NT2, the P-CSCF(IMS-ALG) shall modify the offeror’s destination address(es) and/or port(s) contained in the application signalling message body.
6. P-CSCF propagate the session establishment toward the terminating party. It shall also include additional SIP header (e.g. P-ANI header) to indicate its satellite access information such as satellite ID and optionally local tunnel endpoint info.
7. P-CSCF receives the terminating end SDP with additional SIP header containing information about terminating point satellite access (e.g. P-ANI header) indicating its satellite access information such as satellite ID and optionally remote tunnel endpoint info. The remote tunnel endpoint might change for different satellite.
8. On receipt of the terminating end SDP in the session establishment response, the P-CSCF(IMS-ALG) shall pass the information to the IMS-AGW-NT2 in the Configure AGW Connection Point procedure and shall request the IMS-AGW-NT2 to configure transport resources (T2) via the Configure AGW Connection Point. It can optionally include the terminating point satellite access information (remote tunnel endpoint info).
9. AGW-NT2 shall configure the terminating side transport endpoint (T2).
10. AGW-NT2 sends ack for T2 configuration complete.
11. The P-CSCF(IMS-ALG) shall pass the information (originating side) to the IMS-AGW-NT2 in the Configure AGW Connection Point procedure and shall request the IMS-AGW-NT2 to allocate transport resources (T1) via the Reserve and Configure AGW Connection Point.
12. AGW-NT2 reserve resources for T1.
13. Once the AGW-NT2 configures itself (T1), it acknowledges to P-CSCF.
14. Based on the T1 resource reservation, P-CSCF modifies the SDP and sends a modified SDP answer in 200 OK to the originating side UE.
15. The P-CSCF then releases the resources from the (source) IMS-AGW-NT1.

Editor’s Note: SA3-LI WG is input is needed to validate, if the relocation of AGW has any impact on the LI architecture.



**Figure 6.X.3.5-3: Simultaneous change of UL CL for session continuity**

The above call flow is based on clause 4.3.6.7 from TS 23.502.

UE has an established PDU Session with a UPF, including the PDU Session Anchor (Ground UPF). The PDU Session user plane involves at least the Source (R)AN, Source UL CL and the ground UPF (PDU Session Anchor, PSA), where Source UL CL and AGW-NT may be directly connected (no routing necessary), but routing can be supported.

The below steps, except for steps 5 onwards, are executed between steps 15 and 16 in the above diagram. The step 5 onwards are executed after step 28 in the above diagram.

1. SMF decides to change the UL CL due to UE mobility (change of satellite).

2. The SMF selects a UPF and, using N4 establishes the Target UL CL for the PDU Session. SMF provides the necessary (for SIP signalling) uplink forwarding rule towards the PSA, including the tunnel info for the ground UPF. If session continuity upon UL CL relocation is used, the SMF also uses N4 to establish an N9 forwarding tunnel between the Source UL CL and Target UL CL, including the Tunnel Info for each UPF. In addition, the AN Tunnel Info to target (R)AN is provided for downlink forwarding to the target UL CL. In the case of UL CL, the SMF provides traffic filters indicating what traffic shall be forwarded towards PSA and Source UL CL, respectively. The target UL CL is configured with UL PDR/FAR to point to source UL CL and the source UL CL is configured with DL PDR/FAR to point to target UL CL.

NOTE 1: When session continuity upon UL CL relocation is used, the downlink traffic at this point goes through Source UL CL, Target UL CL and Target (R)AN.

3. The SMF updates the PSA via N4. It provides the PDU Session CN Tunnel Info for the downlink traffic. The Ground UPF now points to target UL-CL (for SIP signalling).

4. The SMF updates (R)AN via N2 SM information over N11. It provides the new CN Tunnel Info corresponding to the Target UL CL.

NOTE 2: When session continuity upon UL CL relocation is used, the uplink traffic destined to Source AGW-NT at this point goes through Target (R)AN, Target UL CL and Source UL CL and then to Source AGW-NT.

5. When the P-CSCF receives the resource allocation information in step 28 in Figure 6.X.3.5-2, the P-CSCF shall send a policy\_authorization update by including the new PCC rules based on target AGW resource allocation to PCF. PCF shall send the PCC rule update to SMF. SMF configures the target UL-CL with the filter rules and forwarding rules to point to target AGW-NT. The target UL-CL will then continue to forward the packet belonging to source AGW-NT via source UL-CL (N9) and now start forwarding the packet belonging to target AGW via N6.

6. When session continuity upon UL CL relocation is used, detection of no active traffic over the N9 forwarding tunnel is performed during a time interval provisioned by SMF for User Plane inactivity report in order to release the N9 forwarding tunnel. The detection can be done by Source UL CL, which notifies the SMF of no active traffic over the N9 forwarding tunnel. The SMF releases the Source Branching Point or the Source UL CL.

NOTE 3: It is up to network configuration whether the detection of no active traffic is performed by the Source UL CL or the Target UL CL. As an alternative to the detection of no active traffic.

6.X.4 Impacts on services, entities and interfaces

UE: no impact

IMS

- IBCF: Allows PANI information be sent to the other party of the call but with only (outer IP) addressing information

- P-CSCF

- Upon UE registration subscribe onto the PCF for the UE connectivity via satellite access capable of UE-Sat-UE.

- May support generating/receiving a PANI related to satellite access information.

- Based on PANI associated with the remote party of a call and on the information received from the PCF for the local UE detect that both parties of a call are served by the same satellite constellation.

- When invoking PCF for Authorization of QoS resources and fetching the user location (ANI), request to insert a local N6 breakout point for the corresponding QoS resources and to report addressing information for this local N6 breakout point.

- Send addressing information for the local N6 breakout point (received from PCF) to the other end of the call via SIP signalling.

- The identification and insertion of AGW onboard satellite, where LI is applicable.

PCF

* Support subscription for the UE connectivity via satellite constellation
* Support a request to insert a local N6 breakout point for the corresponding QoS resources and to report (outer IP) addressing information for this local N6 breakout point and transform this request into relevant PCC rules. Furthermore, notifies the consumer (P-CSCF) when receiving from the SMF (outer IP) addressing information for the local N6 breakout point.

SMF

* based on the PCF request (PCC rule) to insert a local N6 breakout point,
	+ allocates for the Session (a) I-UPF(s) on the satellite currently serving the UE.
	+ configures the UPF(s) to act as UL CL (to break out only traffic corresponding to the SDP indicated by the PCF) and/or as L-PSA (local N6 breakout point);
	+ retrieve from the L-PSA UPF the local (outer IP) addressing information corresponding to the local N6 breakout point.
	+ Provides the remote (outer IP) addressing information to the L-PSA UPF.
* reports to the PCF ANI that contains both the location information received from the RAN and (outer IP) addressing information corresponding to the local N6 breakout point (and retrieved from the L-PSA).

UPF

* Provides to SMF the local (outer IP) addressing information corresponding to the network instance in a PDR.
* Detects based on the remote (outer IP) addressing information that some traffic is to be locally switched at the UPF (based on FAR/Forwarding Rules/ Outer Header creation containing the L-PSA own outer IP address)

\*\*\* END of changes \*\*\*