

# Dynamic Policy Control (Rx)

## Ericsson Service-Aware Policy Controller

### FACILITY DESCRIPTION

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## **Abstract**

This document describes the Dynamic Policy Control functionality provided by the SAPC.



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# 1 Dynamic Policy Control Introduction

This document describes the Dynamic Policy Control function of the SAPC.

This function provides Policy and Charging Control (PCC) differentiated per subscriber for services that are dynamically negotiated taking into account information received from the Application Function (AF) over the Rx interface.

## 2 Dynamic Policy Control Function

### 2.1 Dynamic Policy Control Overview

The SAPC Dynamic Policy Control functionality adheres to the architecture of the standardized PCRF function of the 3GPP PCC architecture, its defined policy control interfaces (Gx, Rx), and logical network elements (PCEF, AF). The AF provides session and service information to the SAPC. The SAPC makes authorization and policy decisions, and sends the appropriate PCC rules to the PCEF, by using the PCRF initiated IP-CAN session modification procedure. This provides a mechanism for the AF to adapt dynamically the service delivery in the transport plane to the required conditions.

When a subscriber wants to establish a session with an AF, such as the P-CSCF or a streaming server, application level signalling is started. Examples of application level signalling include using the Session Initiation Protocol (SIP) in the case of the P-CSCF or the Real Time Session Protocol (RTSP) in the case of a streaming server. The AF notifies the activation of a session using the Rx protocol, and includes dynamic session information. The SAPC then generates policy control and charging information, and installs the applicable PCC rules in the PCEF with the corresponding QoS parameters.

Depending on the capabilities of the network and the UE, the default bearer can be used to transport the service or a dedicated bearer can be established. If a dedicated bearer cannot be established, the default bearer is shared among all the services running on the IP-CAN session.

Dynamic Policy Control comprises the following functions:

- Negotiation of Rx interface version and features supported for the AF session
- Session binding: associate the AF session with an existing IP-CAN session
- Classification (identification) and authorization of dynamic services
- Generation of dynamic PCC rules

- Allocation of QoS and Charging parameters to the authorized dynamic services
- Re-evaluation of previous policy decisions taken for the IP-CAN session, which includes:
  - Allow or reject IP-CAN session access
  - List of static and preconfigured services that are authorized for the IP-CAN session
  - QoS and charging parameters allocated to services currently running in the IP-CAN session
  - QoS parameters allocated to the default IP-CAN bearer
- Provisioning and removal of PCC rules and default bearer QoS to the PCEF
- Notification of bearer events to the AF
- IMS related P-CSCF procedures, such as gating control, Single Radio Voice Call Continuity, SIP forking support and Provisioning of AF Signalling Flow Information

There are different network scenarios where Dynamic Policy Control is applied, and some of the previous functions are only performed in particular network scenarios. The service information provided by the AF can include information such as the set of IP flows required to deliver the service, the type of media (for example, audio, video), the application identifier, the requested bandwidth. This information is used by the SAPC to identify, authorize, and control one or more dynamic services, according to the configured policies and conditions. However, dynamic PCC rules are only generated when the AF provides information about the IP flows required to deliver the service.

Figure 1 shows a high-level flow of the establishment of a dynamic service that makes use of the IP Multimedia Subsystem. In this case, the service delivery (for example, multimedia telephony) requires the establishment of dedicated bearers. During IMS session negotiation, the AF (P-CSCF) derives the service information and performs a resource allocation request towards the SAPC for the media being setup. The SAPC associates the received service data flows with an existing IP-CAN session and creates a set of policy rules for the media negotiated, which triggers the PGW to create a new dedicated bearer for the media type negotiated.

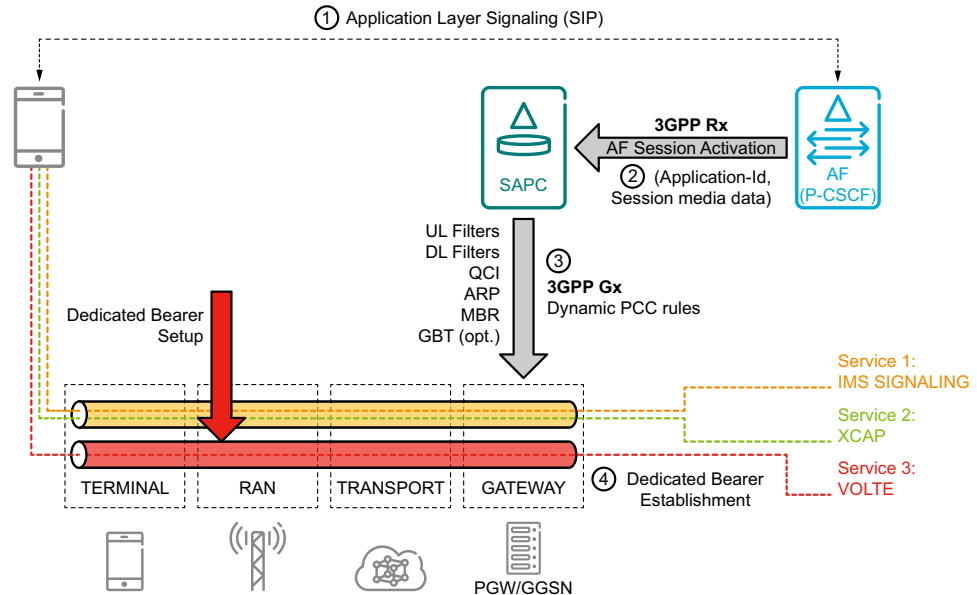


Figure 1 AF session establishment with session media data

In other network scenarios, the AF merely provides an application identifier over the Rx interface, and no specific information on the characteristics of the media session being established (session media data). This identifier is used by the SAPC to trigger the activation of a dynamic service, and to reevaluate the policy information associated with the services that are running on the IP-CAN session. As the IP flows required to deliver the service are not provided, the SAPC cannot generate dynamic PCC rules. Policy control is then performed by Service Access and Charging Control, and IP-CAN Bearer QoS Control. In this case, the SAPC updates the QoS for the default bearer or sends preconfigured PCC rules to indicate to the PCEF that a dedicated bearer must be established.

The following examples describe scenarios where the AF only provides partial service information to the SAPC:

- A DPI node, that acting as an AF node towards the SAPC, indicates the establishment of a dynamic service over the Rx interface.
- A third-party application server or content provider (OTT) contacts the SAPC for authorizing the dynamic services and the QoS resources required for a negotiated application layer session.

Figure 2 shows a high-level flow of the establishment of a dynamic service from a DPI node acting as AF. The DPI node performs packet inspection on the data flow and detects when the user contacts a third-party content provider to start a video streaming service. The DPI node informs the SAPC about the activation of the streaming service, and the SAPC adapts the QoS of the default bearer to guarantee the service delivery.

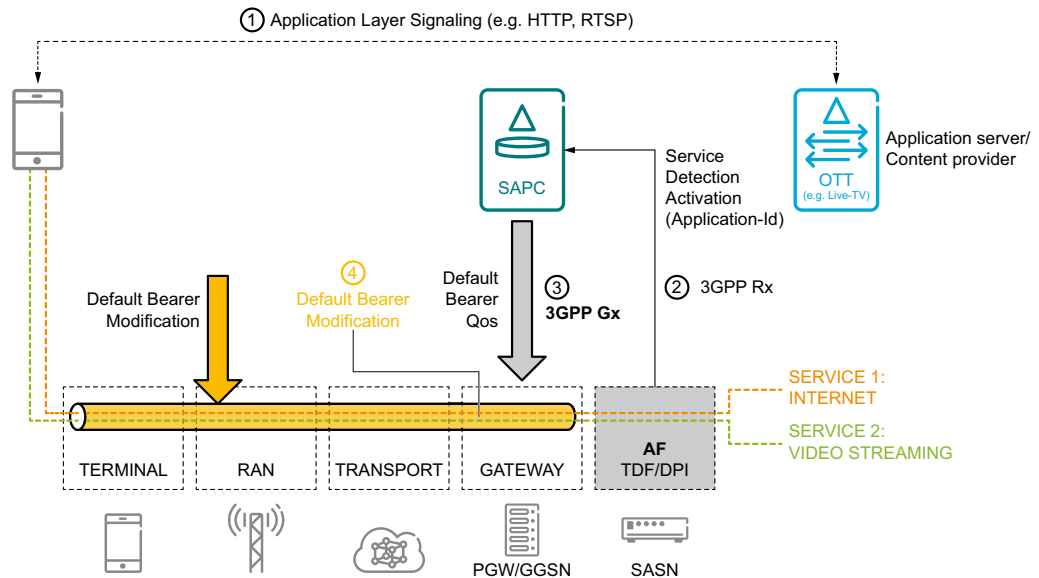


Figure 2 AF session establishment without session media data

## 2.2 Negotiation of Rx Interface Version and Supported Features

During session establishment, the AF indicates the set of supported features required for the AF session. The SAPC indicates, in the first answer message, the set of supported features that it has in common with the AF and that the SAPC supports during the lifetime of the session. The set of supported features includes the Rx interface version and the set of optional features required for the AF session.

The AF provides the required Rx interface version in the initial AA-Request (AAR) command within the Supported-Features AVP. Only one instance of Supported-Features AVP with a Feature-List-ID of value 1 shall be provided, the SAPC ignores any additional feature lists. In addition, the SAPC ignores the value of Supported-Features AVP during AF session modification, if present in the AAR command.

The SAPC provides the negotiated Rx interface version in the initial AA-Answer (AAA) command within the Supported-Features AVP, only when the AF session establishment is successfully completed. If the AF is unable to interoperate using Rx Release 9 onwards, the SAPC rejects the AF session establishment with an error code according to the following:





- If the AF only supports Rx interface Release 7 standard, and therefore the Supported-Features AVP is absent from the AAR command, the SAPC returns DIAMETER\_MISSING\_AVP (5005)
- If the AF requests session establishment with Rx interface Release 8 standard, the SAPC returns DIAMETER\_INVALID\_AVP\_VALUE (5004)

## 2.3 Session Binding

Session binding is the association of the AF session information with an IP-CAN session.

The SAPC performs session binding only during AF session establishment. As a result from the session binding function, the SAPC identifies what IP-CAN session the current AF session is related to, and associates the described service IP flows in the AF session information with that IP-CAN session. Policy control decisions derived from AF session interactions are enforced in the associated IP-CAN session.

The SAPC must receive enough information in AA-Request message to bind the AF session to a single existing IP-CAN session. If the SAPC is not capable of executing the session binding or finds several candidate IP-CAN sessions to bind to, the SAPC sends an AA-Answer command to the AF with the Experimental-Result-Code AVP set to IP-CAN\_SESSION\_NOT\_AVAILABLE (5065).

The SAPC associates the AF session to the single IP-CAN session in function to the AVPs received over Rx interface according to the following order:

- 1 If the SAPC receives the Subscription-Id, the Called-Station-Id and the Framed-IP-Address (or Framed-IPv6-Prefix) AVPs:  
the SAPC compares the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), the administrative subscriber identifier (mapped from Subscription-Id AVP), and the PDN information with the information received through the Gx interface.

In case SAPC does not find any candidate IP-CAN session to bind to, the session binding fails and the SAPC answers AF session establishment with an error. But if the subscription information received through the Rx interface is of type SIP-URI and the administrative subscriber identifier is not defined for the SIP-URI subscription information, the SAPC attempts to perform the binding as stated by the next items.

- 2 If the SAPC receives the IP-Domain-Id AVP through the Rx interface:  
the SAPC performs the association by comparing the domain identity (IP-Domain-Id AVP) with the PCEF identity (Origin-Host AVP) and other AVPs (the Called-Station-Id, the Subscription-Id, the Framed-IP-Address and the Framed-IPv6-Prefix) with the information received through the Gx interface according to preset directives.



The SAPC provides a configurable mapping between the Origin-Host received through the Gx interface and the IP-Domain-Id received through the Rx interface to correlate the PCEF identity with the domain identity.

The SAPC performs the session following these directives:

- a If the Called-Station-Id and the Framed-IP-Address (or Framed-IPv6-Prefix) AVPs are available:  
the SAPC compares the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), the PDN information, and the domain identity (IP-Domain-Id AVP) with the information received through the Gx interface.

In case SAPC does not find any candidate IP-CAN session to bind to, the session binding fails and the SAPC answers AF session establishment with an error.

- b If the Subscription-Id and the Framed-IP-Address (or Framed-IPv6-Prefix) AVPs are available:  
the SAPC compares the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), the administrative subscriber identifier (mapped from Subscription-Id AVP), and the domain identity (IP-Domain-Id AVP) with the information received through the Gx interface.

In case SAPC does not find any candidate IP-CAN session to bind to, the session binding fails and the SAPC answers AF session establishment with an error. But if the subscription information received through the Rx interface is of type SIP-URI and the administrative subscriber identifier is not defined for the SIP-URI subscription information, the SAPC performs the association based on the user IP address and the domain identity.

- c If the Framed-IP-Address or Framed-IPv6-Prefix AVPs is available:  
the SAPC performs the association by comparing the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), and the domain identity (IP-Domain-Id AVP) with the information received through the Gx interface.

If the user IP address and the domain identity are received and not session matches or more than one session matches, the SAPC answers AF session establishment with error.

- 3 If the SAPC receives the Called-Station-Id and the Framed-IP-Address (or Framed-IPv6-Prefix) AVPs:  
the SAPC compares the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), and the PDN information with the information received through the Gx interface.

If the user IP address and the PDN information are received and not session matches or more than one session matches, the SAPC answers AF session establishment with error.



- 4 If the SAPC receives the Subscription-Id and the Framed-IP-Address (or Framed-IPv6-Prefix) AVPs:  
the SAPC compares the user IP address (Framed-IP-Address or Framed-IPv6-Prefix), and the administrative subscriber identifier (mapped from Subscription-Id AVP).

In case SAPC does not find any candidate IP-CAN session to bind to, the session binding fails and the SAPC answers AF session establishment with an error. But if the subscription information received through the Rx interface is of type SIP-URI and the administrative subscriber identifier is not defined for the SIP-URI subscription information, the SAPC performs the association based on the user IP address.

- 5 If the SAPC receives the Framed-IP-Address or Framed-IPv6-Prefix AVPs:  
the SAPC performs the association by comparing the user IP address (Framed-IP-Address or Framed-IPv6-Prefix).

The administrative subscriber identifier is used to correlate the Subscription-Id AVPs received through the Rx interface with the information received through the Gx interface. The SAPC obtains the administrative subscriber identifier that is used for session binding, as follows.

- If multiple Subscription-Id AVPs are received through the Rx message, the SAPC selects one of them, based on configuration, to locate the administrative subscriber identifier.
- If the selection of subscription identifier type is not configured, the first received Subscription-Id AVP is selected.

It is possible to have several Rx sessions (from either the same or different AF nodes) that bind to the same IP-CAN session. Moreover, dual stack IPv6v4 IP-CAN sessions may have associated several IPv4 Rx sessions and several IPv6 Rx sessions at the same time.

To perform session binding in those networks handling IP address overlapping with the same PCEF (refer to *Access and Charging Control (Gx)*), the SAPC must receive Called-Station-Id information at AF session creation. For the case of IP address overlapping among different PCEFs, the SAPC must receive IP-Domain-Id or Subscription-Id AVP.

## 2.4 Classification of Dynamic Services

This function determines the services that are dynamically activated in the SAPC from information provided by the AF through the Rx interface. The AF provides session and service information (session media data) to the SAPC in the AA-Request command. The session media data (when provided) is structured into media components in the AA-Request command, which represent different data flows from the point of view of the AF. The SAPC makes use of this information to trigger the activation of one or more dynamic services, according to the configured conditions in the policies for dynamic service classification. The association

between dynamic services and media components is fully flexible, so that a dynamic service in SAPC may comprise one or several AF media flows.

Dynamic service classification is performed at:

- AF session establishment
- Modification of an existing AF session to add new media

Dynamic service classification is a global policy in SAPC, meaning that it is applied to all active subscribers and subscriber groups. When a dynamic service is activated for a subscriber, it remains active until the AF terminates the session or removes the media stream that corresponds to the service. Modification of the AF session to update the characteristics of the media streams (session media data such as the IP flows, the requested bandwidth) does not trigger a re-evaluation of the policies for dynamic service classification.

The following information received from the AF can be evaluated to classify dynamic services:

- AF application identifier

It is the identifier of the service for which the user has negotiated the bearer resources. If SIP is used, the AF application identifier is extracted from the SIP headers.

- Media type

It is the type of media negotiated for a session component. For example, AUDIO, VIDEO, DATA, and TEXT.

- Destination ports

IP port or port range used to deliver the application service, which corresponds to the destination port of the uplink traffic or source port of the downlink traffic of the negotiated Session Media Data.

The SAPC evaluates the policies for Dynamic Service Classification, and the result of the service classification is the service identifier. The conditions (policy rules) to classify dynamic services can be configured in SAPC to match a wide range of media patterns received from the AF, in particular it is possible to classify:

- Dynamic services that comprise all media components in the AF session
- One dynamic service per media component in the AF session
- Dynamic services that have no media components associated (when no session media data is received from the AF, but only the AF application identifier)
- Dynamic services with an undefined number of media components



Figure 3 shows examples of service classification patterns and the associated dynamic service identifier.

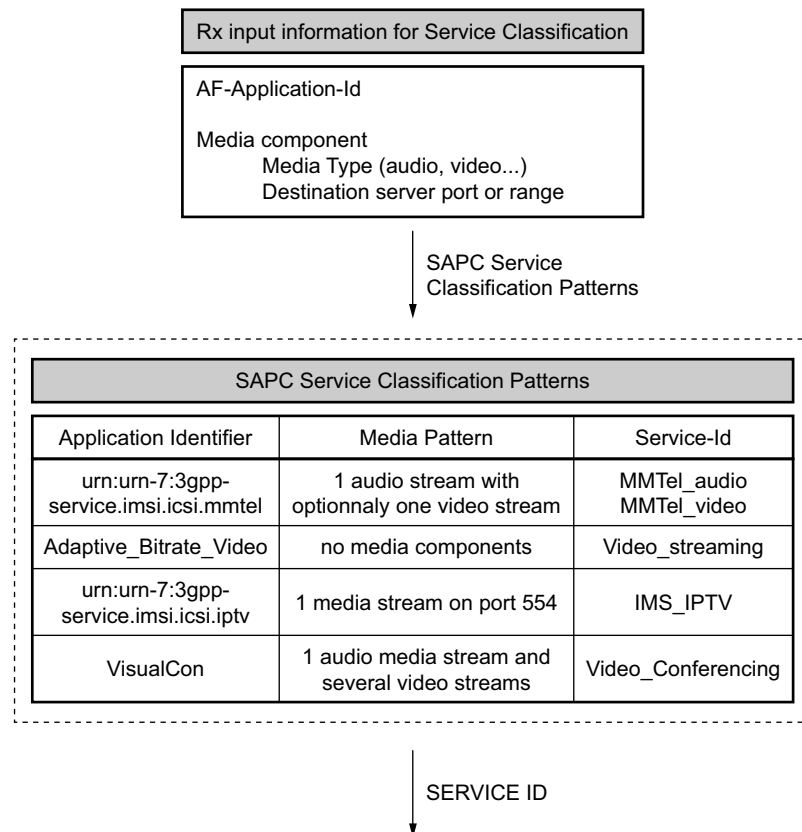


Figure 3 Example of dynamic service classification patterns

The output service identifier of the classification process is used as a reference to perform subsequent service authorization and qualification.

If there are no policies defined in the SAPC to match the information received in the AA-Request command and classify the relevant dynamic services, then the SAPC responds to the AF with an AA-Answer command including the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063), and creates a log.

## 2.5 Authorization of Dynamic Services

This function determines whether dynamic services are authorized for a given subscriber or subscriber group, under certain conditions (policies). By default, dynamic services are authorized.

Dynamic service authorization is performed in the following conditions:

- When a new dynamic service is classified for a subscriber as a result of

- AF session establishment
  - Modification of an existing AF session to add new media
- During IP-CAN session reauthorization because of IP-CAN session modification or PCRF-initiated reauthorization

There are two ways to manage the authorization of dynamic services, by configuring a list of restricted services (a blacklist), or by service authorization policies.

First, the SAPC evaluates if the dynamic service is blacklisted according to the corresponding subscriber or subscriber group profile. If the dynamic service is blacklisted, the service is not authorized.

In addition, the SAPC can use information received from the access network as input for the service authorization decision, such as the Radio Access Technology and the Subscriber Location Information. To make the service authorization decision, the SAPC evaluates the policies for service authorization with the service identifier obtained during the classification process as resource.

**Note:** Time of day (ToD) policies are not supported in dynamic service authorization.

The actions taken by the SAPC when a dynamic service is classified but not authorized are different from the actions taken when a dynamic service currently running in the IP-CAN session becomes not authorized as a result of a change in the dynamic conditions that are evaluated.

### Authorization of New Dynamic Services

If the result of the authorization of a newly classified dynamic service is positive, the SAPC completes the AF session establishment and returns a successful AA-Answer command. If the dynamic service is not authorized, the SAPC responds to the AF with an AA-Answer command including the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063), and the service is not established in the IP-CAN session.

### Reauthorization of Existing Dynamic Services in the IP-CAN session

During IP-CAN session reauthorization, the SAPC evaluates again the policies to decide whether a dynamic service that is running in the IP-CAN session continues to be authorized. This enables SAPC to detect if the service blacklist or the information received from the access network has changed.

If the result of the authorization of an existing dynamic service is negative, the SAPC removes the corresponding PCC rule(s) from the IP-CAN session. In addition, the SAPC informs the AF (only if the AF has previously requested the subscription to INDICATION\_OF\_RELEASE\_OF\_BEARER or INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION events) that the service has been deactivated.



When all the services in the AF session are no longer authorized, the SAPC informs the AF by sending an `Abort-Session-Request` (ASR) command. However, when there are still authorized services in the AF session, the SAPC informs the AF by sending a `Re-Auth-Request` (RAR) command including the list of service data flows that have been deactivated.

## 2.6 Qualification of Dynamic Services

After dynamic services are successfully classified and authorized, the SAPC determines the associated QoS information and the Charging parameters. If the dynamic service comprises AF media flows, this process results in the QoS information and the charging parameters associated with the dynamic PCC rules generated for the service. However, if the dynamic service has no media components associated, no dynamic PCC rules are generated with QoS and Charging information, and this functionality does not apply.

Dynamic service qualification is performed at:

- AF session establishment with associated media components
- Modification of an existing AF session
- IP-CAN session reauthorization because of IP-CAN session modification or PCRF-initiated reauthorization

The output of the qualification of a dynamic service is a QoS profile and Charging profile that contain the authorized QoS and Charging information for the dynamic PCC rules generated for the service. For newly established dynamic services, this process, together with the generation of dynamic PCC rules, results in new PCC rules sent to the PCEF in a `Re-Auth-Request` command. For existing dynamic services, the SAPC evaluates again the policies for qualification of dynamic service to detect changes. If the QoS or Charging information differs from what has been provisioned to the PCEF, the SAPC updates the existing PCC rules by sending a `Re-Auth-Request` command to the PCEF.

The SAPC determines the QoS and Charging information associated with a dynamic service evaluating service QoS policies and service Charging policies, respectively, according to the following precedence allocation:

- 1 Subject policy locator.
- 2 Subject group policy locator.
- 3 Global policy locator.

In case there are conflicts among the rules within a policy, the result for the policy depends on the Rule combining algorithm configured. Refer to “Solving Policies Conflicts” section in *Subscription and Policy Management*.

However, if there are not applicable policies, or the policies are not fulfilled, the SAPC obtains the QoS and Charging profile statically assigned to the dynamic service.

**Note:** Time of day (ToD) policies are not supported in dynamic service qualification.

### 2.6.1 Allocation of QoS Information to Dynamic Services

The QoS information includes the QoS class identifier (authorized QoS class for the service data flow), the Allocation and Retention Priority (ARP) and authorized bit rates for uplink and downlink

To get the QoS Information associated with the dynamic service, the SAPC evaluates the QoS policies that apply to the service identifier that is obtained from the Dynamic Service Classification procedure. These policies can take into account subscriber information, access network information provided by the PCEF and media session information provided by the AF.

The QoS information is assigned per media component. For dynamic services that comprise several AF media flows, it is possible to allocate different QoS profiles to the different AF media components by including conditions such as the media type in the policy rules.

If the AF media component contains two subflows to deliver the service (two media subcomponents), the SAPC assigns the QoS information to each of the AF media subcomponents according to the usage indicated for this particular IP flow in the Flow-Usage AVP.

- If the media sub-component is used to transport media data such as RTP, the SAPC assigns the QoS profile obtained.
- If the media sub-component is used to transport media signalling data (RTCP), the SAPC generates the QoS information as follows:
  - The QCI and ARP values are set to the same value as in the QoS profile obtained.
  - The MBR value is obtained as 5% of the MBR value in the QoS profile obtained.
  - The GBR value (if applicable) is obtained as 5% of the GBR value in the QoS profile obtained.

If the QoS profiles obtained after the policy evaluation do not provide values for the QCI, MBR, or GBR, the SAPC applies the procedure defined in 3GPP to calculate the value of those QoS parameters.

This procedure is defined in Policy and Charging Control signalling flows and QoS parameter mapping, TS 29.213, chapter QoS parameter mapping Functions at PCRF.





- QCI is assigned depending on the media type and whether the IP flows are unidirectional or bidirectional, as shown in the next table.

Session Media Data	QoS Class Identifier
Media-Type AVP is not present	QCI = 9
Media-Type AVP set to AUDIO or VIDEO	QCI = 2, if IP flows are bidirectional QCI = 4, if IP flows are unidirectional
Media-Type AVP set to APPLICATION	QCI = 2
Media-Type AVP set to DATA	QCI = 8
Media-Type AVP set to CONTROL	QCI = 6
Media-Type AVP set to TEXT, MESSAGE, OTHER	QCI = 9

- The MBR for the flows used to transport media data (RTP) in the uplink and downlink is obtained from the Max-Requested-Bandwidth-UL AVP and Max-Requested-Bandwidth-DL AVP respectively. If the AF does not provide the maximum requested bandwidth for an IP flow, the SAPC omits the MBR value in the dynamic PCC rule for this IP flow. If the AF does not provide a Flow-Description AVP in either the uplink or the downlink direction, the SAPC sets the MBR value to zero (0) in this direction.
- The MBR for the RTCP flows is obtained by applying this calculation:
  - The MBR for uplink = RS-Bandwidth + RR-Bandwidth
  - The MBR for downlink = RS-Bandwidth + RR-Bandwidth
  - If the RR-Bandwidth AVP is not received from the AF, the MBR assigned is the maximum of the value of the RS-Bandwidth and the 5% of the MBR assigned to the RTP flow
  - If the RS-Bandwidth AVP is not received from the AF, the MBR assigned is the maximum of the value of the RR-Bandwidth and the 5% of the MBR assigned to the RTP flow
  - If the RR-Bandwidth AVP and the RS-Bandwidth AVP are not received from the AF, the MBR assigned is the 5% of the MBR assigned to the RTP flow
- The GBR is assigned the same value as the MBR for both, the RTP and the RTCP flows. The GBR value is only included in the PCC rule for QCI values that are defined in 3GPP as standard GBR QCIs (1 to 4, 65, 66, 75) or for other QCI values that have been explicitly configured in the SAPC as GBR QCIs.

If there are not applicable policies, or the policies are not fulfilled, the SAPC obtains the QoS profile provisioned to the dynamic service (static qualification).

## 2.6.2 Allocation of Charging Parameters to Dynamic Services

The charging parameters define the Service Identifier, Rating Group, Reporting Level, Metering Method, and whether the online and offline charging interfaces are used.

To obtain the charging profile associated with a dynamic service, the SAPC evaluates the charging policies that apply to the service identifier that has been obtained in the Dynamic Service Classification procedure. These policies can take into account subscriber information, access network information provided by the PCEF and media session information provided by the AF. If there are not applicable policies, or the policies are not fulfilled, the SAPC obtains the Charging profile provisioned to the dynamic service (static qualification).

The charging information is assigned per media component associated with the dynamic service. Therefore, all dynamic PCC rules created for the same media component contain the same charging information.

For dynamic services that comprise several AF media flows, it is possible to allocate different Charging profiles to the different AF media components by including conditions such as the media type in the policy rules.

If the Charging profile obtained after the policy evaluation do not provide any of the optional charging parameters, this information is omitted from the dynamic PCC rule. Finally, if the procedure cannot obtain a charging profile, no charging information is included in the dynamic PCC rule

## 2.7 Generation of Dynamic PCC Rules

The SAPC receives information about the session that the user has negotiated with the AF through the Rx interface. This triggers the establishment of one or more dynamic services, by following the process of Dynamic Service Classification and Authorization. If the AF provides information about the IP flows required to deliver the service (media component information), the SAPC generates the policy control and charging information in the form of PCC rules. These dynamic PCC rules are installed in the PCEF through of the Gx protocol.

The SAPC generates one dynamic PCC rule for every media sub-component received from the AF. New dynamic PCC rules are generated when new dynamic services are established (that is, AF session establishment or modification of an existing AF session to add new media). Modification of the characteristics of existing dynamic services (that is, AF session modification) triggers a modification of the PCC rules that have been previously provisioned to the PCEF.

Figure 4 shows the relation between the AF service information received through the Rx interface and the PCC rule information that is generated by the SAPC and installed in the PCEF using the Gx interface.

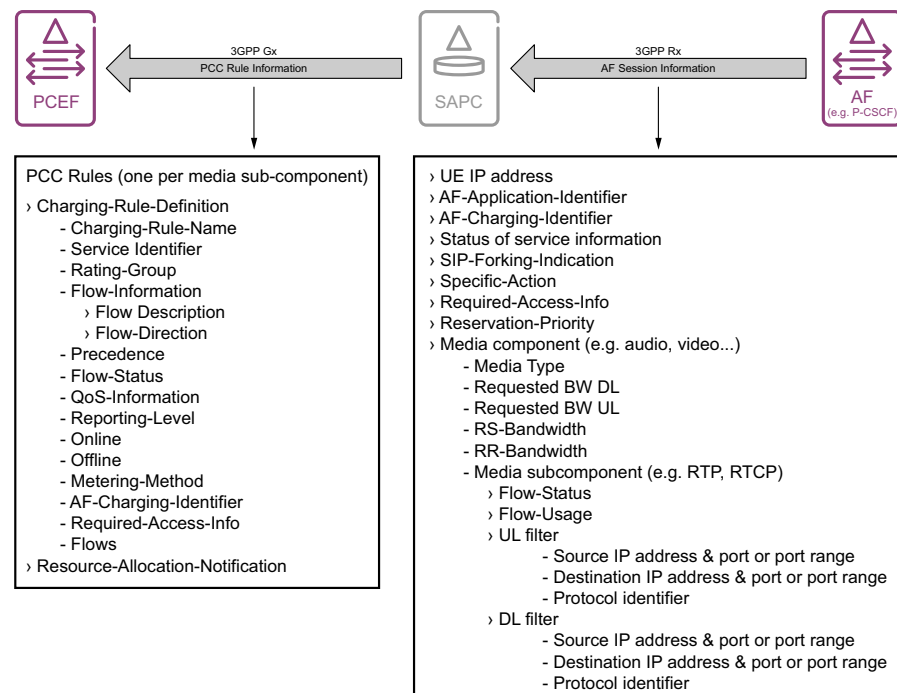


Figure 4 Information received from the AF and provided to the PCEF

The information received from the AF consists of the following (refer to Rx Interface Description for a complete list of supported AVPs):

— UE-IP-Address parameter

The IPv4 or IPv6 address allocated to the terminal attached to the AF. This is a mandatory parameter.

**Note:** In scenarios in which UE IP addresses are reused for different APNs or for different PCEFs (IP address overlapping), the AF must send the Subscription-Id and Called-Station-Id parameters.

— AF-Application-Identifier

The identifier of the particular application service that the AF session belongs to. In IMS deployments, the P-CSCF (AF) derives this information from the IMS communication service requested by the UE.

— AF-Charging-Identifier

The charging identifier used by the AF (for example, for IMS it is the IMS Charging Identifier). This information may be used for charging correlation with the access network charging records.

— Service-Info-Status

This parameter indicates the status of the service information that the AF provides to the SAPC, whether the application service has been fully negotiated between the two end points or the information is preliminary.

— SIP-Forking-Indication

This parameter indicates whether the AF session relates to a single SIP dialogue or to several SIP dialogues. See Section 2.10.2 on page 27.

— Specific-Action

The traffic plane events (such as release of a bearer) that the AF requires to be notified by the SAPC. See Section 2.9 on page 21.

— Required-Access-Info

This parameter indicates that the AF requests the required access network information. See Section 2.9.4 on page 23.

— Reservation-Priority

The priority assigned to the AF session and media flows in the resource reservation request. The SAPC can take into account this value to assign the Allocation and Retention Priority (ARP) in the PCC rules installed in the PCEF, according to the Dynamic Service Qualification procedure.

— Media Component

It contains service information for a single media component within the AF session. For example, an IMS session for multimedia telephony can have one audio media component and one video media component. This parameter contains a Media-Component-Number, that indicates the ordinal number of the media component. A media component can be divided into several media subcomponents.

- Media-Type

The type of media of a session component, for example, audio or video

- Uplink requested bandwidth

The maximum bandwidth for an uplink IP flow requested by the AF. If the media component contains two media subcomponents, this refers to the bandwidth required to transport the media data (RTP) in the uplink direction.

- Downlink requested bandwidth

The maximum bandwidth for a downlink IP flow requested by the AF. If the media component contains two media subcomponents, this refers to the bandwidth required to transport the media data (RTP) in the downlink direction.



- RS-Bandwidth

The maximum required bandwidth for RTCP sender reports within the session component. This value, together with the RR-Bandwidth, sets the maximum required bandwidth to transport the media control information for an RTP session.

- RR-Bandwidth

The maximum required bandwidth for RTCP receiver reports within the session component. This value, together with the RS-Bandwidth, sets the maximum required bandwidth to transport the media control information for an RTP session.

- Media Subcomponent

Each Media-Subcomponent contains the IP filter definition for a set of IP flows. The IP filter definition describes the uplink or downlink IP flows, including the source and destination IPv4 or IPv6 addresses and ports. In addition, information regarding the Flow-Usage (for example, if the flow is RTCP or RTP) and Gating is included.

- Flow-Number

Ordinal number of the IP flow.

- Flow-Description

Describes the uplink or downlink IP flows. It includes Direction, Source IPv4 or IPv6 address, Destination IPv4 or IPv6 address, Source Port, Destination Port, Protocol.

- Flow-Usage

Set to “RTCP”, if media subcomponent refers to an RTCP flow and “no information” in any other case. It is an optional parameter with default value “NO INFORMATION”.

- Flow-Status

This parameter indicates whether the IP flows are enabled or disabled by the AF. This allows the SAPC to control the traffic flow through the PGW in the user plane (gating functionality). See Section 2.10.1 on page 26.

The SAPC generates the dynamic PCC rules using the information described previously in the Dynamic Services Classification and Service Authorization policies. The SAPC generates the corresponding dynamic PCC rules for each media component, and installs the corresponding PCC rules. There is one PCC rule for each media subcomponent, which implies that there is one PCC rule for each RTP flow and one PCC rule for each RTCP flow. If the SAPC does not receive any media components, no PCC rules are created.



The SAPC generates each PCC rule containing the following information:

— **PCC rule name**

A unique identifier for the PCC rule within the IP-CAN session, provisioned in the Charging-Rule-Name AVP. The SAPC assigns a new value for PCC rules generated when new dynamic services are established. At AF session modification, the PCC rule name remains the same.

The PCC rule name follows a specific format of four elements, delimited by the "|" character, with a maximum size of 63 characters. The PCC rule name begins with the service identifier that results from the dynamic service classification process, then continues with the Media-Component-Number and the Flow-Number, and finally includes a pseudo-random portion derived from the Rx diameter Session-Id.

— **Service Data Flow**

It consists of the Flow-Information, and Flow-Status AVPs included in the PCC rule. This information identifies the uplink and downlink IP flows of a media subcomponent. The SAPC obtains the service data flow from the media subcomponent UL and DL packet filter provided by the AF in the Flow-Description AVP.

— **Precedence**

This parameter determines the order, in which service data flow filters are applied at the PCEF. A PCC rule with lower precedence value shall be applied before a PCC rule with higher precedence value. The SAPC calculates the precedence value according to the completeness of the DL flows of the PCC rule, according to the following criteria:

- If the DL filter of the PCC rule is complete and defined with specific source and destination ports, the SAPC sets the precedence value to zero.
- If some information of the DL filter is missing or incomplete, the precedence value is increased. If the source IP is missing, the precedence is increased by 1. If the source IP is ANY, the precedence is increased by 2. If the source port is a list or a range, the precedence is increased by 1. If the source port is ANY, the precedence is increased by 2. If the destination port is a list or a range, the precedence is increased by 1. If the destination port is ANY, the precedence is increased by 2. If the destination IP is missing, the precedence is increased by 1. If the destination IP is ANY, the precedence is increased by 2.

— **QoS Information**

To generate the QoS-Information AVP that applies to the PCC rule, the SAPC applies the Dynamic Service Qualification procedure.

— **Charging Information:** : The charging information includes the following:



- The SAPC obtains the Rating Group, Reporting Level, Metering Method, and offline or online states by applying the Dynamic Service Qualification procedure.
  - Reporting-Level: Defines on what level the PCEF reports the usage for the related PCC rule. Reporting level can be at a combination of service identifier and rating group, or at rating group level
  - Metering-Method: Defines what parameters are metered for offline charging. Metering method can be duration, volume, or both
  - Offline: Defines whether the offline charging interface from the PCEF for the associated PCC rule is enabled
  - Online: Defines whether the online charging interface from the PCEF for the associated PCC rule is enabled
  - Rating-Group: The charging key for the PCC rule, used for rating purposes
  - Service-Identifier: The identity of the service or service component in the PCEF that the service data flow in a dynamic PCC rule relates to
- AF-Charging-Identifier
 

If the Reporting-Level AVP is set to the value SERVICE\_IDENTIFIER\_LEVEL (0), then the SAPC includes the AF-Charging-Identifier AVP in the dynamic PCC rule. The value of AF-Charging-Identifier is obtained from the data received from the AF.
- Flows
 

The flow identifiers of the IP flows related to a PCC rule, as provided by the AF. The SAPC includes the Flows AVP in the dynamic PCC rule only when the AF-Charging-Identifier AVP is also present.
- **Resource Allocation Notification**

This parameter is included when the allocation of resources for the related PCC rules must be confirmed, as requested by the AF
- **Required Access Info**

This parameter is included when the AF requests to report the access network information.

## 2.8 IP-CAN Session Reauthorization

Establishment, modification and termination of dynamic services also triggers in the SAPC a re-evaluation of all previous policy decisions taken for the IP-CAN session. Examples of the application of session reauthorization owing to dynamic service establishment include the ability to apply Bearer QoS Control, Access and

Charging Control and BW Management to other services running on the IP-CAN session.

Session reauthorization owing to dynamic service establishment is useful in the following example scenarios:

- For scenarios in which only the default bearer is supported, and an IMS service is established. In this case, the SAPC can downgrade the QoS of the rest of the services running on the default bearer, to guarantee IMS service delivery. Alternatively, the SAPC can upgrade the QoS of the default bearer to accommodate all services
- For scenarios in which a DPI box is acting as an AF, and does not provide media component description to the SAPC. In this case, a pre-configured PCC rule can be defined in the SAPC, associated with the activation of a dynamic service, that initiates the establishment of a dedicated bearer for the delivery of the service detected by the DPI box.

The SAPC performs reauthorization of the IP-CAN session at AF session establishment, AF session modification and AF session termination, regardless of the generation of dynamic PCC rules. The SAPC evaluates the applicable policies for the IP-CAN session, to perform the following functionality (refer to *Service Access and Charging Control and IP-CAN Bearer QoS Control*).

- IP-CAN session Access Control
- Service Access Control
- Service Charging Control
- Bearer QoS Control
- Bandwidth Management

The conditions (policy rules) for those functions are extended to be able to apply policy decisions based on the establishment of a dynamic service, as follows.

- Indication of dynamic service establishment

This function indicates if a dynamic service is running in the IP-CAN session, which means that the dynamic service has been successfully classified and authorized. This allows the SAPC for example to authorize and install static or preconfigured PCC rules based on whether a given dynamic service is running or not.

In addition, to calculate the QoS for the default bearer, the SAPC uses the Bearer QoS Control function extended with the following operations that can be used to take policy decisions.

- Maximum QoS for the dynamic services





This function returns a QoS profile composed of the highest value for every field in the QoS profile, out of the values obtained for each dynamic PCC rule running in the IP-CAN session.

- Aggregated QoS for the dynamic services

This function returns a QoS profile composed of the sum of the throughput parameters (GBRs and MBRs) out of the values obtained for each dynamic PCC rule running in the IP-CAN session, and selecting the highest value in the rest of the QoS parameters.

## 2.9 Notification of Bearer Events to the AF

The AF may request the SAPC to be notified about certain events on the user plane, such as when a bearer is released, by using the *Specific-Action* AVP in an initial *AA-Request* command. This enables the AF to react to traffic plane events by application level signalling.

The SAPC supports notification of the following traffic plane events:

- IP-CAN session termination
- Service Data Flow deactivation
- Successful resources allocation
- Network Location Information
- IP-CAN type change notification
- Signalling Path Status

The SAPC sends to the AF one notification message per traffic event, even in situations where several traffic plane events are reported simultaneously by the PCEF. For example, if the PCEF reports in the same *CC-Request* command that one dynamic PCC rule has been successfully installed and another dynamic PCC rule has been deactivated, the SAPC sends two separate *Re-Auth-Request* commands to the AF.

### 2.9.1 IP-CAN Session Termination

When an IP-CAN session is terminated, the SAPC informs the AF about the IP-CAN session termination by sending an *Abort-Session-Request* command to the AF on each active Rx Diameter session. As a result, the AF indicates the termination of the Rx session by sending a *Session-Termination-Request* command to the SAPC.

## 2.9.2 Service Data Flow Deactivation

When a dynamic PCC rule cannot be installed/activated or enforced at the PCEF, the SAPC deactivates the corresponding dynamic service and informs the AF that one or more service data flows have been deactivated. This function enables the AF to react to events in the user plane by sending an AAR command to the SAPC to update the session information or an STR command to terminate the AF session.

The SAPC gets the knowledge that one or more service data flows have been deactivated, on reception of a Charging-Rule-Report AVP in a CC-Request command that includes the PCC-Rule-Status AVP set to the value INACTIVE, the list of failed PCC rules, and the failed reason code. Then the SAPC removes the PCC rule(s) from the IP-CAN session, performs IP-CAN session reauthorization, and notifies the AF if the AF has previously requested subscription to INDICATION\_OF\_RELEASE\_OF\_BEARER or INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION events.

The notification from the SAPC details the affected IP flows, and includes a failure code that indicates the reason of the failure.

- If not all the service data flows within the AF session are reported as INACTIVE and the AF has requested to be notified, the SAPC sends a Re-Auth-Request command and reports the affected IP Flows encoded in the Flows AVP, the type of action encoded in the Specific-Action AVP, and the reason for the failure encoded in the Abort-Cause AVP. The SAPC sets the value of the Specific-Action AVP to match the subscription from the AF.
- When all the service data flows within the AF session are affected, the SAPC sends an Abort-Session-Request command on the Rx Diameter session related to the AF session, that includes the reason for the failure encoded in the Abort-Cause AVP.

The Abort-Cause AVP is set to the value BEARER\_RELEASED in all cases except when the Rule-Failure-Code AVP received from the PCEF is set to PS\_TO\_CS\_HANDOVER (refer to SRVCC for more details).

## 2.9.3 Successful Resources Allocation

The AF may request the SAPC to provide a notification when the resources associated to the corresponding service information have been allocated. In this case, the SAPC requests the PCEF to confirm that the resources associated to the corresponding dynamic PCC rules are successfully allocated, and on reception of the confirmation from the PCEF, the SAPC notifies the AF. This function applies to applications for which the successful resource allocation notification is required for their operation. The drawback is that subscription to this notification impacts the resource allocation signalling overhead towards the PCEF.

The procedure to provide indication of successful resources allocation is detailed in Section 4.3.2 on page 45.



- The AF sets the Specific-Action AVP to the value INDICATION\_OF\_SUCCESSFUL\_RESOURCES\_ALLOCATION in the initial AA-Request command.
- The SAPC derives the dynamic PCC rules from the service information and includes the Resource-Allocation-Notification AVP with the value ENABLE\_NOTIFICATION within the corresponding Charging-Rule-Install AVP(s).
- When resource allocation is successfully completed, the PCEF sends an event trigger indication with the value SUCCESSFUL\_RESOURCE\_ALLOCATION. The affected rules are indicated within the Charging-Rule-Report AVP with the PCC-Rule-Status AVP set to the value ACTIVE.
- On reception of the notification from the PCEF, the SAPC sends a Re-Auth-Request command with Specific-Action AVP set to the value INDICATION\_OF\_SUCCESSFUL\_RESOURCES\_ALLOCATION and the affected IP Flows encoded in the Flows AVP.

#### 2.9.4 Network Location Information

Network Location Information (NetLoc) is an optional function, and the SAPC negotiates its support during Gx and AF session establishment. It enables the SAPC to report one time report network location information during the AF session establishment, modification, or termination.

During the AF session establishment or modification, when the SAPC receives a request to report the access network information (user location or MS timezone, or both) from the AF, the SAPC sets the access network information report parameters in the corresponding PCC rules according to the information required by the AF, and provisions them to the PCEF together with the ACCESS\_NETWORK\_INFO\_REPORT event trigger (refer to *Access and Charging Control (Gx)*, Reference [1] for more information about event triggers).

When the SAPC receives the requested access network information, together with the ACCESS\_NETWORK\_INFO\_REPORT event trigger, from the PCEF:

- User location information and the time when it was last known
- or Serving PLMN identifier
- and/or Time zone

the SAPC provides it to the AF.

During the AF session termination, IP-CAN session termination, or IP-CAN bearer release (if all the service data flows within the AF session are affected), when the SAPC receives the NetLoc request from the AF in the session termination request, the SAPC answers with the corresponding access network information received from the PCEF. During the IP-CAN bearer release, if not all the service data flows within the AF session are affected, the SAPC provides the corresponding access network information in the Rx reauthorization request to the AF.

The SAPC automatically subscribes to the ACCESS\_NETWORK\_INFO\_REPORT event trigger when at least one of the AFs associated to the IP-CAN session requests to report the access network information and this event trigger has not been previously subscribed for the IP-CAN session (therefore it is not required to statically or dynamically associate this event trigger to the subscriber).

#### 2.9.4.1 Network Location Information in Untrusted WLAN access

The SAPC can also provide Netloc information when EPC-based untrusted WLAN access is used (if this function is successfully negotiated at Gx and Rx session establishment).

The difference with previous case is that in this case the SAPC can receive the following WLAN access network information from the PCEF, together with the ACCESS\_NETWORK\_INFO\_REPORT event trigger:

- UE Local IP address (IPv4 or IPv6)
- UDP and/or TCP source port number
- WLAN location information and the time when it was last known
- Serving Network of the ePDG
- Time zone

At reception of the WLAN access network information from the PCEF, the SAPC sends it to the AF (if the AF supports Netloc in Untrusted WLAN function).

#### 2.9.4.2 Network Location Information Reporting Failure Handling

When the AF requests reporting the access network information during the AF session establishment, modification, or termination:

- If the PCEF does not support the access network information reporting, the SAPC responds to the AF indicating that access network information reporting is not supported.
- If the PCEF indicates that the access network currently serving the UE does not support access network information retrieval, the SAPC informs the AF of an access network information reporting failure including also that the access network does not support access network information retrieval as failure reason.
- If the PCEF reports location information from Untrusted WLAN access and the AF does not support Netloc in Untrusted WLAN access feature, the SAPC informs the AF of an access network information reporting failure.



### 2.9.5 IP-CAN Type Change Notification

The IP-CAN Type Change Notification is a mechanism to report the UE's IP-CAN type and Radio Access Technology (RAT) type changes by access network to the AF.

When the SAPC receives the IP-CAN type change information from the PCEF, it sends a reauthorization request to the bound AF session only if the AF has previously subscribed to IP-CAN type change notification at AF session establishment.

During the AF session establishment and modification, the SAPC is able to provide IP-CAN type and RAT type information to the AF. The precondition is that the SAPC already subscribes to the IP-CAN\_CHANGE event trigger and knows the information provided by the PCEF, even though the AF does not subscribe to IP-CAN type change notification.

The SAPC automatically subscribes to the IP-CAN\_CHANGE and RAT\_CHANGE event triggers when at least one of AFs associated to the same IP-CAN session requests subscription to IP-CAN type change notification and these two event triggers are not configured yet. The SAPC is also able to automatically unsubscribe to either one or both of the IP-CAN\_CHANGE and RAT\_CHANGE event triggers that are added due to AF's subscription to IP-CAN type change notification when the following preconditions are fulfilled:

- 1 None of the IP-CAN associated AF sessions is subscribed to IP-CAN type change notification.
- 2 Either one or both of the IP-CAN\_CHANGE and RAT\_CHANGE event triggers are not selected by both static configuration and dynamic policy.

### 2.9.6 Notification of Signalling Path Status

The Notification of Signalling Path Status function enables the SAPC to report the release of signalling transmission path from the PCEF to the AF. The precondition is that the AF subscribes to the notification of signalling path status at AF session establishment.

When receiving the following information from the AF, the SAPC identifies that the AF is requesting subscription to notification of signalling path status:

- Specific action: INDICATION\_OF\_RELEASE\_OF\_BEARER
- Media Component Description
  - Media Component Number: 0
  - A single Media Sub Component
    - Flow Number: 0
    - Flow Usage: AF\_SIGNALLING



The SAPC searches the AF signalling path profile to identify the static or preconfigured service provisioned for the AF signalling, and identifies the corresponding PCC rule. The SAPC sends the PCC rule to the PCEF if the PCC rule has not been previously sent or is changed. When receiving from the PCEF the resource allocation failure for the PCC rule related to the AF signalling path, the SAPC notifies the AF of the release of signalling path by sending a reauthorization request.

If the AF subscribes to the notification of signalling path status but no AF signalling path profile is provisioned, the SAPC still accepts the AF's subscription. In this case, the SAPC can only notify the AF by an abort session request at IP-CAN session termination as introduced in Section 2.9.1 on page 21.

For one IP-CAN session, only one service can be related to an AF signalling path in the SAPC. For multiple AF sessions bound to the same IP-CAN session, only one AF session can successfully subscribe to the notification of signalling path status. It is possible to specify a different AF signalling path per APN and a default one. If the SAPC cannot find the configured service corresponding to the received APN, the SAPC uses the default one.

## 2.10 IMS Related PCC Procedures over Rx

### 2.10.1 Gating Control

This function controls the flow of IP packets through the PCEF according to the information received from the AF. The SAPC receives the Flow-Status AVP from the AF and applies this information to the PCC rules installed on the PCEF. The Flow-Status can be received from the AF for the whole media component or for a media subcomponent. The Flow Status information provided for a media component applies to all IP flows within the media component, for which no corresponding information is being provided within Media-Sub-Component AVPs.

The following values can be used to perform gating:

- ENABLED-UPLINK (0)

This value is used to enable the associated uplink IP flows, and to disable the associated downlink IP flows.

- ENABLED-DOWNLINK (1)

This value is used to enable the associated downlink IP flows, and to disable the associated uplink IP flows.

- ENABLED (2)

This value is used to enable all associated IP flows in both directions.

- DISABLED (3)



This value is used to disable all associated IP flows in both directions.

If a Media-Sub-Component AVP under a Media-Component-Description AVP contains a Flow-Usage AVP with the value RTCP, then the corresponding RTCP IP flows in both directions are enabled, even if the Flow-Status AVP under the Media-Sub-Component AVP is set to ENABLED-UPLINK, ENABLED-DOWNLINK, or DISABLED.

### 2.10.2 Support for SIP Forking

SIP forking is the ability to send SIP request messages to multiple destinations, that correspond to multiple registered contact addresses in the IMS network. This allows the IMS network to attempt simultaneously the establishment of the application session in multiple destinations where the subscriber may be reached. The provisional response from each possible destination is called an early dialog. Upon the reception of the first final response, the IMS releases the remaining early dialogs and completes application session establishment.

During SIP forking, the AF (P-CSCF) receives provisional responses from more than one terminating end point, and requests authorization and resources to the SAPC to accommodate for the most demanding early dialog. Each provisional response may have different service requirements (different IP flows, requested bandwidth, and so on), and it is not known which terminating endpoint will finally accept the application session until the final response is received. This implies that when the P-CSCF receives the first final response, only the media flows negotiated for this particular early dialog are authorized for the IMS session.

The procedure to support SIP forking is depicted in Figure 5.

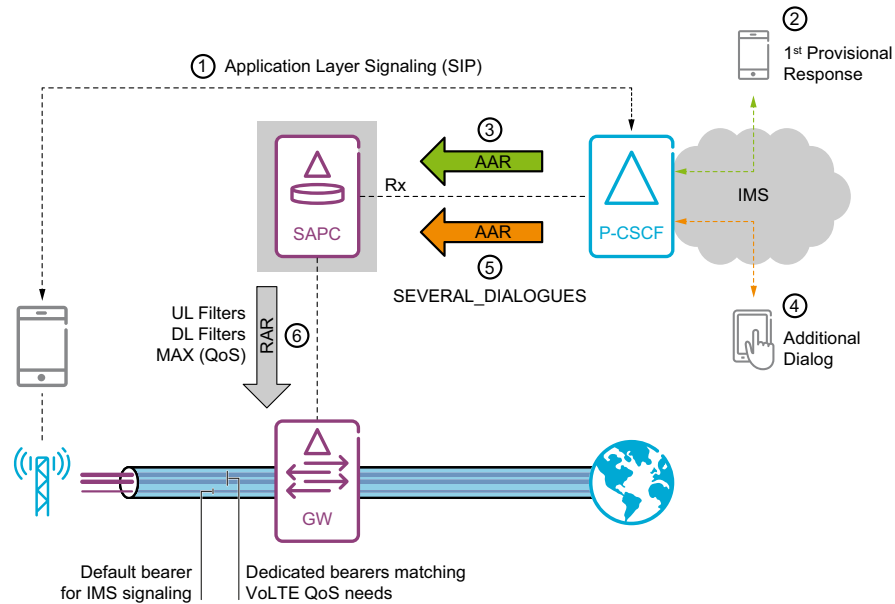


Figure 5 Overview of SIP Forking functionality

After the first AF session is established, for each subsequent provisional response establishing an extra early dialog, the P-CSCF sends an AA-Request command within the existing Diameter session containing the SIP-Forking-Indication AVP with the value SEVERAL\_DIALOGUES, and includes the service information derived from the latest provisional response.

Upon reception of service information for provisional responses, the SAPC authorizes any additional media components and any increased QoS requirements for the previously authorized media components. The SAPC authorizes the maximum bandwidth required by any of the dialogues, but not the sum of the bandwidths required by all dialogues. Thus, the SAPC updates the installed dynamic PCC rules and adds additional service data flow filters for each of the early dialogs, so that the QoS authorized for a media component is equal to the highest QoS requested for that media component by any of the forked responses.

The SAPC opens or closes the gates for service flows according to the Flow Status information received from the AF. However, if a media flow has been enabled within previous service information, it shall remain enabled even if the SAPC receives service information that disables this flow ID within an AAR containing the SIP-Forking-Indication AVP with value SEVERAL\_DIALOGUES.

When receiving the first final SIP response, the P-CSCF sends an AA-Request command without the SIP-Forking-Indication AVP, and includes the full service information (applicable IP flows, requested bandwidth, and so on) derived from the dialogue of the final response.

When the SAPC receives an AA-Request command with no SIP-Forking-Indication AVP or with a SIP-Forking-Indication AVP with value





**SINGLE\_DIALOGUE**, the SAPC updates the installed PCC rules information and QoS information to match only the requirements of the service information within this AA-Request. The SAPC also removes the PCC rules or individual service data flow filters not matching IP flows provided in the final response, and performs gating control according to the flow status information received in the final response.

### 2.10.3 Single Radio Voice Call Continuity (SRVCC)

Single Radio Voice Call Continuity (SRVCC) refers to the transfer of an IMS Multimedia Telephony call from the PS domain to the CS domain, when the UE can transmit and receive on only one of those access networks at a given time.

During the SRVCC procedure, the SAPC receives an indication from the PCEF that one or more PCC rules cannot be maintained because of PS to CS handover. The SAPC then informs the AF (only if the AF has previously requested the subscription to **INDICATION\_OF\_RELEASE\_OF\_BEARER** or **INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION** events) that the bearer has been deactivated owing to PS to CS handover.

The procedure to support SRVCC is depicted in Figure 6.

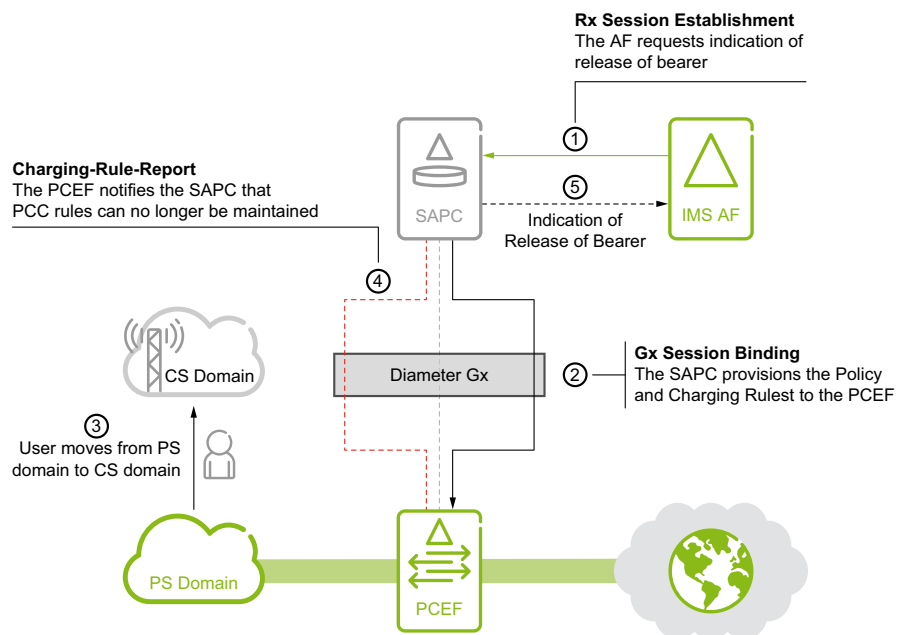


Figure 6 Overview of SRVCC functionality

When the IMS session is transferred from the PC domain to the CS domain, the PCEF sends a CC-Request command with a Charging-Rule-Report AVP that identifies the PCC rules that can no longer be maintained, and includes the PCC-Rule-Status AVP set to the value **INACTIVE** and the

Rule-Failure-Code AVP set to the value PS\_TO\_CS\_HANDOVER. Then, the SAPC notifies the AF by using either a Re-Auth-Request command or an Abort-Session-Request command, including the Abort-Cause AVP set to the value PS\_TO\_CS\_HANDOVER.

- If not all the service data flows within the AF session are reported as INACTIVE and the AF has requested to be notified, the SAPC sends a Re-Auth-Request command and reports the affected IP Flows encoded in the Flows AVP and the type of action encoded in the Specific-Action AVP.
- When all the service data flows within the AF session are affected, the SAPC sends an Abort-Session-Request command on the Rx Diameter session related to the AF session.

## 2.10.4 Provisioning of AF Signalling Flow Information

Provisioning of AF Signalling Flow Information is a supported feature, part of the IMS Restoration Procedures specified in 3GPP TS 23.380, to handle a P-CSCF service interruption scenario with minimum impact to the service to the end user.

After UE registration to IMS, AF (P-CSCF) sends to the SAPC information about the AF signalling flows between the UE and the AF. The SAPC installs the corresponding dynamic PCC rules (if not installed before) by triggering an RAR message in order to convey the AF address the UE is using to the PCEF. The PCEF monitors all P-CSCF nodes being used by the UEs and if a P-CSCF becomes unresponsive, the PCEF requests all UEs using this P-CSCF to do a new registration against another P-CSCF.

The procedure to support Provisioning of AF Signalling Flow Information IMS Restoration Procedure is depicted in Figure 7.

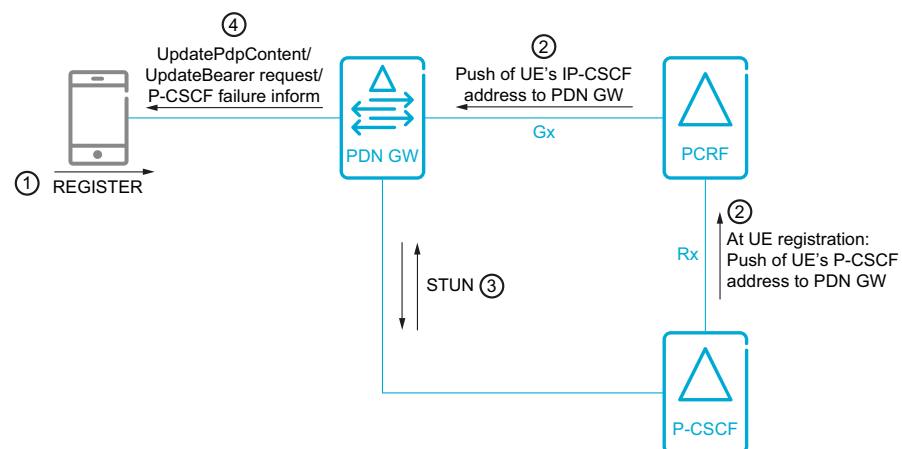


Figure 7 Overview of Provisioning of AF Signalling Flow Information functionality



## 2.11 Handling of Race Conditions Related to Multiple AF Requests

Network scenarios where multiple AF sessions are bound to the same IP-CAN session may lead to race conditions, due to traffic events that happen concurrently or within a short time frame. This situation may result in a state mismatch, where the wrong information is being maintained by the PCEF, the SAPC and/or the AF for the session.

Diameter race conditions may happen in the following situations:

- Concurrent PCEF-initiated and AF-initiated IP-CAN session modifications.

The main use case has been found in scenarios where the AF requires notification of successful resources allocation, which results in an increased rate of Credit-Control-Request (CCR) update messages from the PCEF to the SAPC. The problem occurs when a SAPC-initiated IP-CAN session modification (possibly triggered by AF interaction) overlaps in time with a PCEF-initiated IP-CAN session modification (possibly to notify the successful outcome of a previous session modification).

- Multiple AF requests within a short time period.

The main use case has been found in scenarios where the AF performs multiple Rx session creation/modification requests in short succession for the same user. This triggers SAPC to send Gx RAR messages at a high rate, potentially triggering a new session modification before the previous Gx RAR message has been acknowledged.

The SAPC is able to handle diameter race conditions, not only triggered by AF interactions but also due to other internal or external events that overlap in time. Refer to *Access and Charging Control (Gx)* for a complete functional description.

The procedure to handle race conditions due to multiple AF requests is as follows:

- When the SAPC receives a diameter AAR message from the AF, the SAPC answers AAA as usual, and follows the procedures described in *Access and Charging Control (Gx)*.
- Other AF interactions that occur for the same IP-CAN session during the time period where the SAPC is waiting for acknowledgment of an RAR message, do not trigger a modification of the IP-CAN session. The SAPC updates the AF session information, sends the AAA message and waits until the end of the time period or reception of the RAA message.
- When the RAA message is received or the timer expires, the SAPC performs the pending session reauthorization and sends a new RAR message including all the pending policy information to be communicated to the PCEF.
- If the RAA includes the result code `DIAMETER_PENDING_TRANSACTION` or `DIAMETER_OUT_OF_SPACE`, the new RAR message also contains information

about the policies that failed to be enforced in the PCEF, as described in Access and Charging Control (Gx).

- If the SAPC receives a CCR-U message when there is a previous Gx RAR pending to be acknowledged, the SAPC performs a session re-authorization depending on the event received in the CCR-U message, as usual. However, if the AF has requested the SAPC to report the access network information for this IP-CAN session, the SAPC skips policy evaluation for static, preconfigured, and dynamic services until the Gx RAA message is received or the timer expires.

## 2.12 Delay PCC Rules Installation for AF Sessions with Preliminary Service Information

Mobility events can disrupt the call setup phase for VoLTE calls, causing them to release. This is caused because the network and the devices are not fully ready to support SRVCC during pre-alerting and alerting phases.

In order to mitigate these effects, the SAPC can delay the installation of PCC rules for AF sessions with preliminary service information that needs to be further negotiated between the two ends, and can allocate the network resources (i.e. the dedicated bearers) only when the service has been fully negotiated between the two ends and the service information provided is the result of that negotiation..

This is a non-standard procedure that is configured by a flag set by Ericsson personnel. By default, the SAPC installs dynamic PCC rules for preliminary and final AF sessions. When toggled, the SAPC:

- does not install PCC rules when the service information provided by the AF is preliminary, i.e. PCC rules generated for preliminary AF sessions.
- classifies, authorizes and stores the Media Subcomponents while the service information provided by the AF is preliminary.
- installs the dynamic PCC rules generated from the stored Media Subcomponents when the AF session becomes final (i.e. when the service information is fully negotiated).
- if the SAPC receives a CCR-U message for an IP-CAN session bound to one or more preliminary AF sessions, the SAPC performs a session re-authorization depending on the event received in the CCR-U message, as usual, but it does not generate, install or remove any dynamic PCC rule when all services contain preliminary service information.
- if the AF requests NetLoc information while the service information provided by the AF is preliminary, this request is delayed until any of the AF sessions becomes final.



## 3 Dynamic Policy Control Network Deployments

The SAPC can provide Dynamic Policy Control in the following network elements:

— In the bearer plane (PCEFs) side:

- Ericsson EPG, through Ericsson Gx+ Rel9 onwards.
- Non-Ericsson PCEF, through standard Gx Rel9 onwards.

**Note:** The SAPC also supports multiple PCEFs deployments for Dynamic Policy Control.

— In the application plane (AF) side:

- Ericsson SBG, through standard Rx Rel9 onwards.
- Non-Ericsson AF, through standard Rx Rel9 onwards.

## 4 Dynamic Policy Control Traffic Cases

This chapter explains the interfaces involved in Dynamic Policy Control.

This chapter explains the traffic interactions between the network nodes involved in Dynamic Policy Control. For detailed description of each of the interfaces supported, the corresponding interface description should be consulted.

The precondition to all traffic cases is that a diameter connection is already established between the SAPC and the PCEF and between the SAPC and the AF. In addition, all the required policy controls are enabled for the PCEF, and support for dynamic PCC rules is enabled for the GGSN/PDN GW.

- The Service Access policy control is required to perform authorization of dynamic services.
- The Bearer QoS policy control is required to allocate QoS Information to dynamic services.
- The Service Charging policy control is required to allocate charging Information to dynamic services.

The Session-Id is a mandatory AVP for all the messages in the Rx protocol, to identify an AF session uniquely.

The precondition to all traffic cases is as follows:

- The availability of this function in the SAPC is under license control, otherwise SAPC rejects any Rx message by answering with Result-Code `DIAMETER_UNABLE_TO_COMPLY=5012`.
- The number of simultaneous Rx sessions has not reached the hard limit of the corresponding licensed Rx sessions capacity, otherwise SAPC rejects any new Rx session creation by answering with Result-Code `DIAMETER_UNABLE_TO_COMPLY=5012`.

## 4.1 AF Session Lifetime

This chapter shows the most common traffic cases that may happen during the life cycle of the AF session (establishment, modification, and termination), in network scenarios where the AF provides information about the IP flows required to deliver the service (media component information). The precondition for all traffic cases is that the UE has established an IP-CAN session.

### 4.1.1 AF Session Establishment

The following figure shows the signalling flow that takes place during AF session establishment and the main actions taken by the SAPC to perform dynamic policy control. This traffic case includes the scenario where network initiated bearers are supported (Bearer Control Mode is set to `UE_NW`), and also the scenario where network initiated bearers are not supported (Bearer Control Mode is set to `UE_ONLY`).

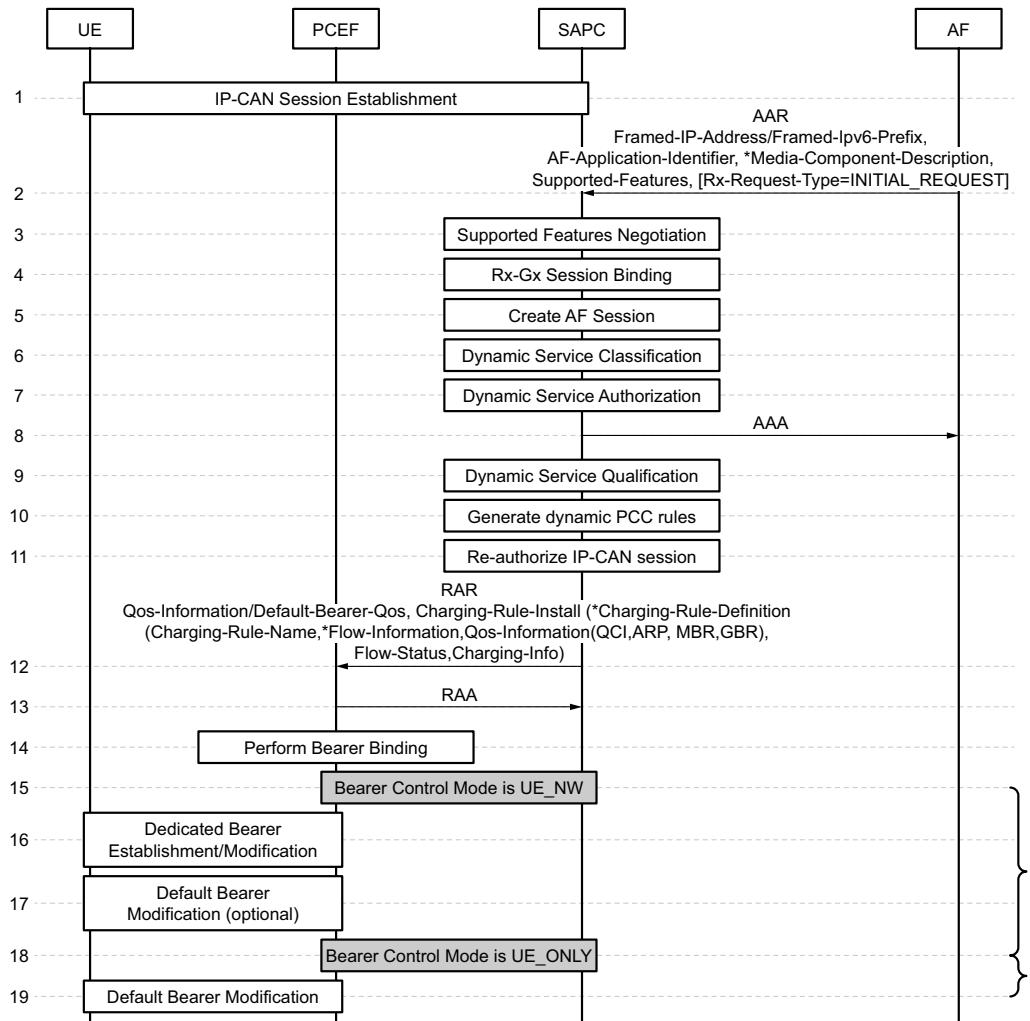


Figure 8 AF Session Establishment

- 1 The UE has established an IP-CAN session.
- 2 The SAPC receives an AAR message from the AF to establish a new AF session. The main information that the AF provides is:
  - The IPv4 or IPv6 address that identifies the UE terminal.
  - The AF-Application-Identifier AVP that typically permits to identify the particular service that the AF session belongs to.
  - The Media-Component-Description AVP(s), that contain service information for each media component within an AF session. This parameter includes the set of IP flows required to deliver the service, the type of media, the flow status information, and the requested bandwidth.

- The set of supported features required for the AF session, in the Supported-Features AVP.
  - Optionally, the following information may be also provided by the AF:
    - The charging identifier used by the AF, in the AF-Charging-Identifier AVP
    - The status of the service information provided by the AF, in the Service-Info-Status AVP.
    - The Called-Station-Id AVP and Subscription-Id AVP to assist session binding.
    - The priority assigned to the AF session, in the Reservation-Priority AVP.
    - The Rx-Request-Type AVP indicating INITIAL\_REQUEST (0).
  - If the Rx-Request-Type AVP is not received, the SAPC checks if there is an AF session created with the same received Session-Id. If an AF session already exists, continue in Section 4.1.2 on page 37, step 4.
- 3 The SAPC determines the set of supported features that it has in common with the AF, according to Section 2.2 on page 4.
    - If the Supported-Features AVP is not present in the AAR command, the SAPC rejects the AF session establishment with the error code DIAMETER\_MISSING\_AVP (5005).
    - If the AF requests session establishment with Rx interface Release 8, the SAPC returns the error code DIAMETER\_INVALID\_AVP\_VALUE (5004).
  - 4 The SAPC performs session binding and associates the AF session information with an existing IP-CAN session, according to Section 2.3 on page 5. If session binding is not successful, the SAPC sends an AAA command to the AF with the Experimental-Result-Code AVP set to IP-CAN\_SESSION\_NOT\_AVAILABLE (5065).
  - 5 The SAPC creates an AF session for this subscriber's request, linked to the bound IP-CAN session.
  - 6 The SAPC identifies the set of services corresponding to the AF session by performing the Service Classification (see Section 2.4 on page 7). If no dynamic service is successfully classified, then the SAPC rejects the AF session establishment with the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063).
  - 7 The SAPC determines if the classified dynamic services are authorized, according to Section 2.5 on page 9. If any of the dynamic services is not authorized, the SAPC rejects the AF session establishment with the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063).





- 8 The SAPC responds to the AF with an AA-Answer command indicating the operation result. If the request is successfully, the Result-Code AVP is set to the value SUCCESS. If the request is unsuccessful, an error code is indicated in either the Result-Code AVP (for generic diameter error codes) or in the Experimental-Result AVP (for Rx-specific error codes).
- 9 The SAPC determines the QoS and Charging information associated with the dynamic services that have been classified and authorized, by evaluating the service qualification policies. See Section 2.6 on page 11.
- 10 The SAPC generates the policy control and charging information in the form of dynamic PCC rules. One dynamic PCC rule is generated for every media sub-component received from the AF. See Section 2.7 on page 14.
- 11 The SAPC performs reauthorization of the IP-CAN session to reevaluate the previous policy decisions taken for the IP-CAN session according to the applicable policies. This permits for example to perform Service QoS Control and BW Management to remove or apply less bandwidth to other services that are running on the default bearer. The SAPC also performs Bearer QoS Control and calculates the quality of service that applies to the default bearer.
- 12 The SAPC sends to the PCEF the dynamic PCC rules including the QoS information for each PCC rule, the charging information, and the QoS information for the default bearer if necessary (this is, only if it differs from default bearer QoS information already provisioned to the PCEF). If the Bearer QoS policy control is not enabled for the PCEF, the SAPC sends the dynamic PCC rules with no QoS information. In addition, the SAPC may provision other PCC rules and policy decisions that result from the reauthorization of the IP-CAN session, within the same RAR command.
  - In 3GPP-GPRS access, the SAPC sends the quality of service information of the default bearer in the QoS-Information AVP.
  - In 3GPP-EPS access, the SAPC sends the quality of service information of the default bearer in the Default-EPS-Bearer-QoS AVP.
- 13 The PCEF accepts the installation of PCC rules.
- 14 The PCEF performs the bearer binding and modifies the default bearer (if applicable), according to the Bearer Control Mode selection.

#### 4.1.2

#### AF Session Modification

The following figure shows the signalling flow that takes place during AF session modification and the main actions taken by the SAPC to perform dynamic policy control. The AF session modification may only update the service information for existing media components, but may also add new media components and remove media components. Gating control is another scenario of AF session modification, where the AF signals the SAPC if the IP flow(s) are to be enabled or disabled to pass through the IP-CAN. This traffic case includes the scenario where network initiated bearers are supported (Bearer Control Mode is set to UE\_NW),

and also the scenario where network initiated bearers are not supported (Bearer Control Mode is set to UE\_ONLY).

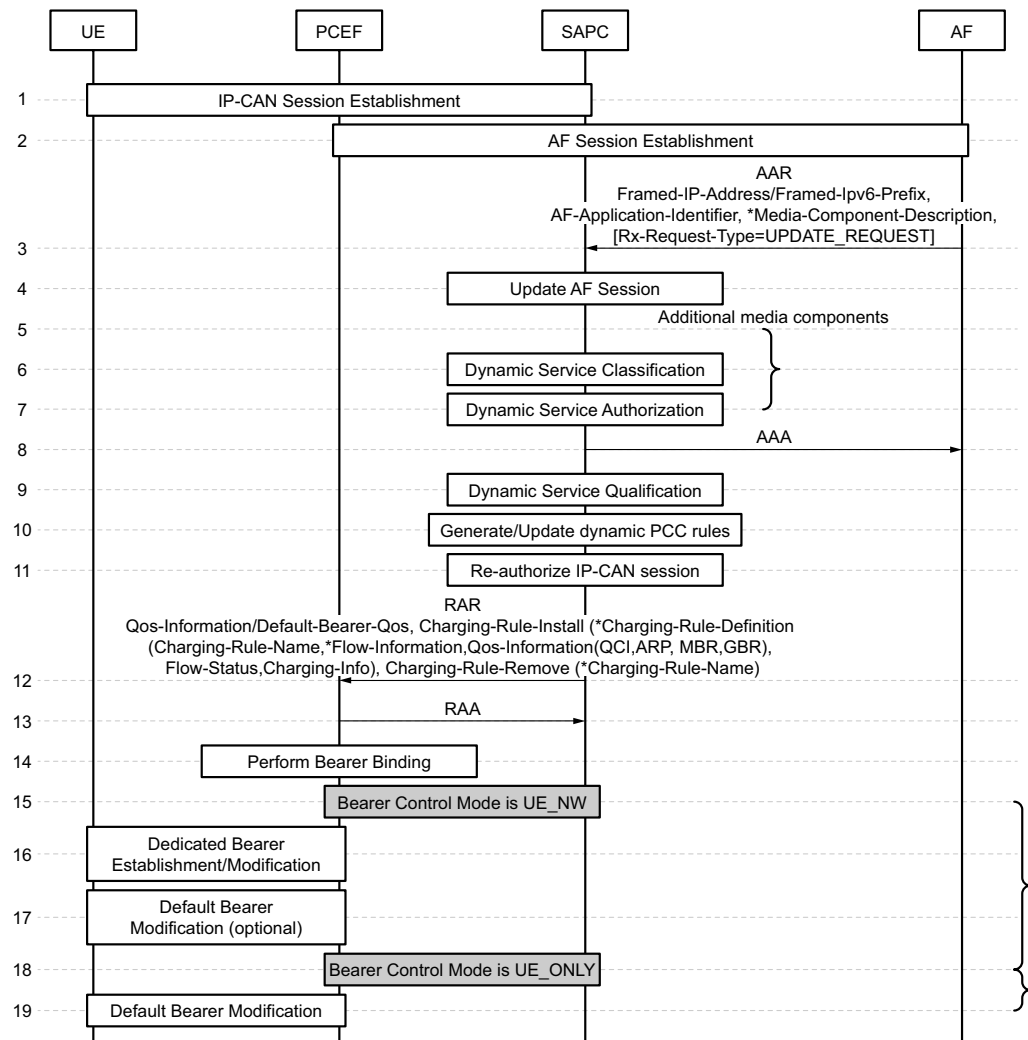


Figure 9 AF Session Modification

- 1 The UE has established an IP-CAN session.
- 2 The AF performs the session establishment procedure, as detailed in Section 4.1.1 on page 34.
- 3 The SAPC receives an AAR message from the AF to modify an existing AF session including the session identifier that identifies the AF session. The main information that the AF provides is the Media-Component-Description AVP(s) with the updated service information for each media component. If a Media-Component-Description AVP is not supplied by the AF, or if optional AVP(s) within a Media-Component-Description AVP are omitted, but



corresponding information has been provided in previous Diameter messages, the previous information for the corresponding IP flow(s) remains valid.

- If the AF performs gating control, the Media-Component-Description AVP(s) contains the flow status information, in the Flow-Status AVP, for the flows that are enabled or disabled to pass through the PCEF. See Section 2.10.1 on page 26 for more details. A typical use case is when the P-CSCF (AF), before the completion of the SIP session setup, enables or disables the media IP flows depending on operator policy, thus allowing or forbidding early media to be transferred end-to-end.
- If the AF modifies the requirements to deliver the application service (such as the set of IP flows, the requested bandwidth), the Media-Component-Description AVPs contain the updated service information for each media component in the AF session that needs to be modified. A typical example is when the P-CSCF (AF) modifies the bandwidth required to deliver the service because of the final negotiation of the codecs to be used end-to-end.
- If the AF adds a media flow to the Rx session, the AAR command contains a Media-Component-Description AVP with a new ordinal number in the Media-Component-Number AVP.
- If the AF removes a new media flow from the Rx session, the AAR command contains a Media-Component-Description AVP with the Flow-Status AVP set to the value REMOVED.

Optionally, the AF may also provide the Rx-Request-Type AVP indicating UPDATE\_REQUEST (1).

- 4 The SAPC updates the AF session state for this subscriber's request, according to the information provided by the AF.
- 5 If the SAPC identifies that the updated AF session contains new media components, the SAPC performs the dynamic service classification and authorization.
- 6 The SAPC identifies the set of new services to be added to the AF session by performing the Service Classification only for the additional media components. If the new media component(s) cannot be successfully classified, then the SAPC rejects the AF session modification with the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063).
- 7 The SAPC determines if the newly classified dynamic services are authorized, according to Section 2.5 on page 9. If any of the new dynamic services is not authorized, the SAPC rejects the AF session modification with the Experimental-Result-Code AVP set to the value REQUESTED\_SERVICE\_NOT\_AUTHORIZED (5063).
- 8 The SAPC responds to the AF with an AA-Answer command indicating the operation result. If the request is successfully, the Result-Code AVP is set to the value SUCCESS. If the request is unsuccessful, an error code is indicated.

- 9 The SAPC determines the QoS and Charging information associated with the new and existing dynamic services in the AF session, by evaluating the service qualification policies. See Section 2.6 on page 11.
- 10 The SAPC generates the new dynamic PCC rules, modifies the existing dynamic PCC rules, or deletes existing dynamic PCC rules in the IP-CAN session, depending on the information provided by the AF to add new media, update existing media or remove media components.
- 11 The SAPC performs reauthorization of the IP-CAN session to reevaluate the previous policy decisions taken for the IP-CAN session according to the applicable policies. The SAPC also performs Bearer QoS Control and calculates the quality of service that applies to the default bearer.
- 12 The SAPC provisions the policy control and charging information to the PCEF.
- 13 The PCEF accepts the installation of PCC rules and performs bearer binding according to the Bearer Control Mode selection at IP-CAN session establishment.

### 4.1.3

### AF Session Termination

The following figure shows the signalling flow that takes place during AF session termination and the main actions taken by the SAPC to perform dynamic policy control.

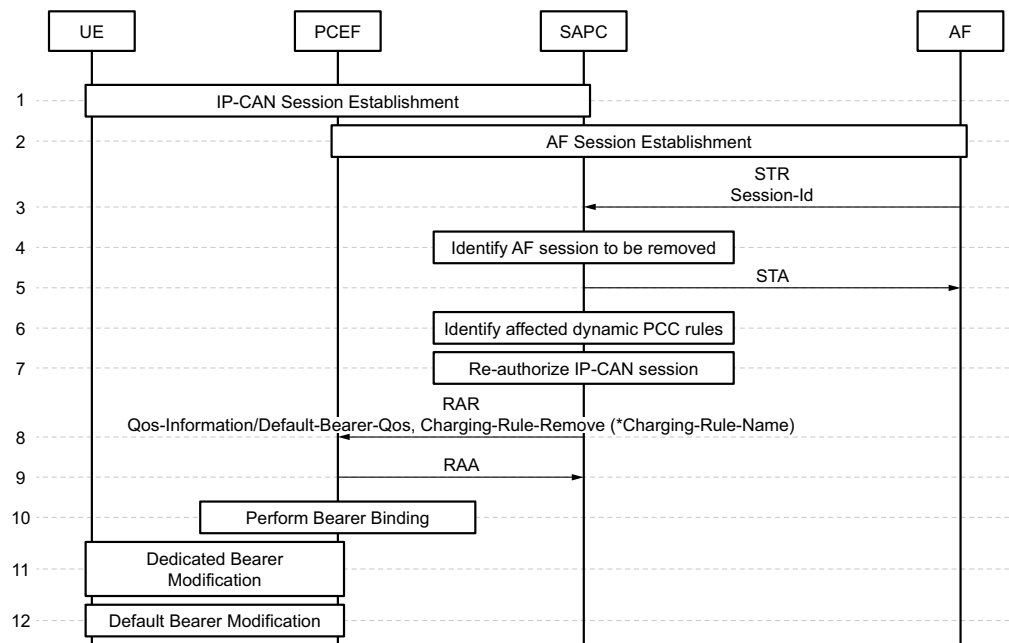


Figure 10 AF Session Termination

- 1 The UE has established an IP-CAN session.



- 2 The AF performs the session establishment procedure, as detailed in Section 4.1.1 on page 34.
- 3 The AF sends an STR to indicate the termination of the AF session.
- 4 The SAPC removes the AF session. If the SAPC cannot find the AF session to be removed, the SAPC rejects the AF session termination and returns the Result-Code AVP set to the value DIAMETER\_UNKNOWN\_SESSION\_ID.
- 5 The SAPC accepts the termination of the AF session, and responds to the AF with a Session-Termination-Answer command indicating the operation result with value SUCCESS.
- 6 The SAPC identifies the affected PCC rules in the IP-CAN session.
- 7 The SAPC performs reauthorization of the IP-CAN session to reevaluate the previous policy decisions according to the applicable policies. The SAPC also performs Bearer QoS Control and calculates the quality of service that applies to the default bearer.
- 8 The SAPC sends an RAR command to the PCEF to remove the affected PCC rules, and the QoS information for the default bearer if necessary. In addition, the SAPC may provision other PCC rules and policy decisions that result from the reauthorization of the IP-CAN session, within the same RAR command.
- 9 The PCEF accepts the removal of the PCC rules, and the modification of the default bearer (if applicable).
- 10 The PCEF performs the bearer binding and modifies the default bearer (if applicable), according to the Bearer Control Mode selection at IP-CAN session establishment.

## 4.2 Reauthorization of Dynamic Services

The following figure shows the signalling flow that takes place during IP-CAN session modification triggered by the PCEF, and the main actions taken by the SAPC to perform dynamic policy control. An example of use case is when the operator has established a policy to authorize only a particular dynamic service (for example video media from the AF) for specific access networks or subscriber location.

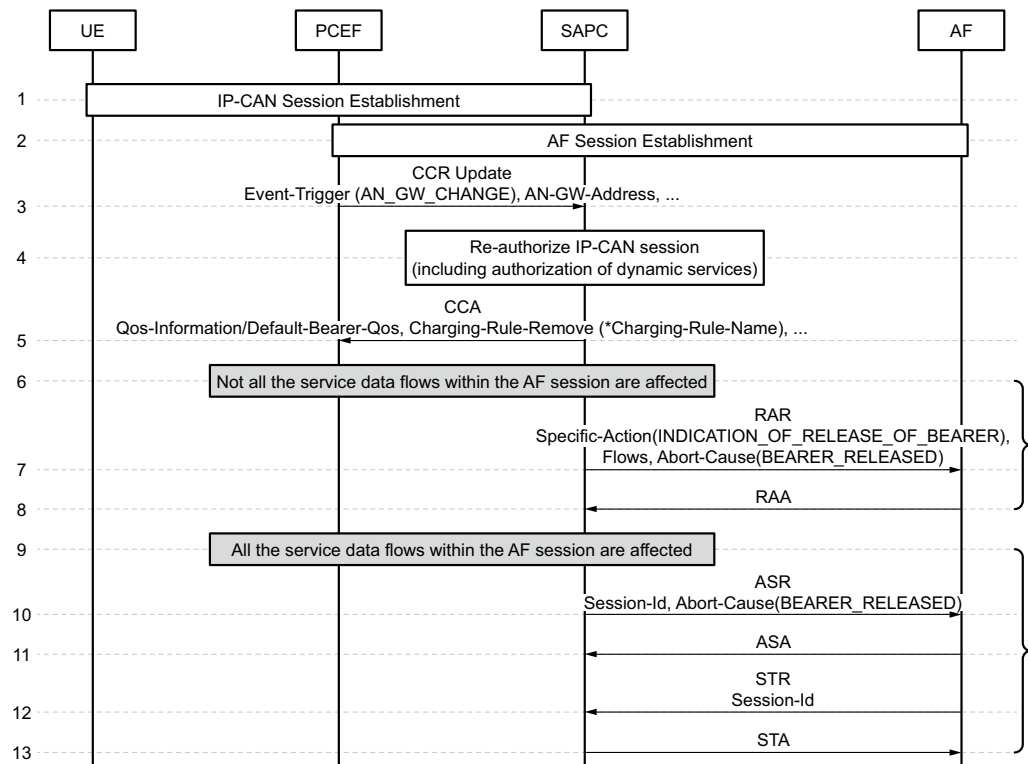


Figure 11 Reauthorization of Dynamic Services during IP-CAN Session Modification

- 1 The UE has established an IP-CAN session.
- 2 The AF performs the session establishment procedure, as detailed in Section 4.1.1 on page 34. In addition, the AF subscribes to the Specific-Action AVP of type INDICATION\_OF\_RELEASE\_OF\_BEARER. The SAPC authorizes the dynamic services and sends the PCC rules to the PCEF.
- 3 The SAPC receives a CCR Update message from the PCEF indicating IP-CAN session modification, and the new/modified parameters together with the associated event-triggers. In this use case, the CCR Update message indicates that the serving Access Node gateway has changed to the value encoded in the AN-GW-Address AVP.
- 4 The SAPC performs reauthorization of the IP-CAN session, including the reauthorization and qualification of all dynamic services running in the IP-CAN session, according to the applicable policies and the new information received. If the result of the authorization of an existing dynamic service is negative, the SAPC deactivates the dynamic service and removes the corresponding PCC rule(s) from the IP-CAN session.
- 5 The SAPC sends a CCA message to the PCEF including only the new/modified Policy and Charging Control information.



- 6 If any of the existing dynamic services in the IP-CAN session is not authorized, the SAPC notifies the AF:
  - 7. When there are still authorized services in the AF session, the SAPC informs the AF by sending an RAR command with Specific-Action AVP set to the value INDICATION\_OF\_RELEASE\_OF\_BEARER, including the list of service data flows that have been deactivated in the Flows AVP and the reason for the failure set in the Abort-Cause AVP to the value BEARER\_RELEASED.
  - 10. When all the services in the AF session are rejected, the SAPC informs the AF by sending an ASR command including the reason for the failure set in the Abort-Cause AVP to the value BEARER\_RELEASED.

After sending the ASR command, the SAPC decreases the counter of active AF sessions.

## 4.3 Notification of Bearer Events

### 4.3.1 Service Data Flow Deactivation

The following figure shows the signalling flow that takes place when dynamic PCC rules cannot be installed/activated or enforced at the PCEF, and the main actions taken by the SAPC to perform dynamic policy control.

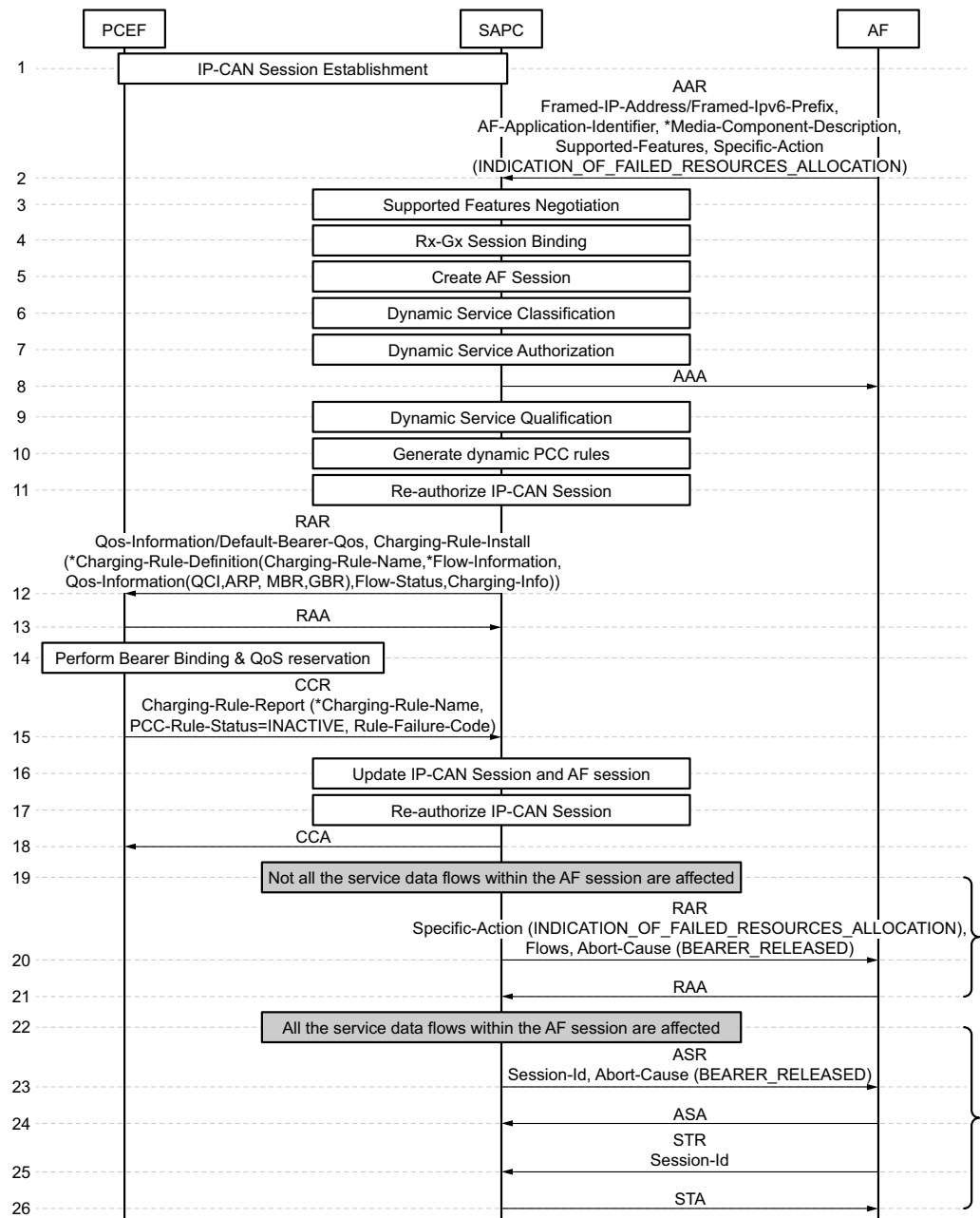


Figure 12 Notification of Inactive Service Data Flows to the AF

- Steps 1–14 are similar to the ones explained in section AF Session Establishment. Next, the main differences are highlighted.
- 2. In addition to the service information, the SAPC receives the list of bearer events that the AF requests to be notified in the Specific Action AVP. In this use case, the AF subscribes to Specific Action of value INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION,





however the AF may also subscribe to Specific Action of value INDICATION\_OF\_RELEASE\_OF\_BEARER or to both notification events.

- 15. The PCEF sends a CCR-Update that includes a Charging-Rule-Report AVP with the PCC-Rule-Status AVP set to the value INACTIVE, the list of failed PCC rules, and the failed reason code detailed in the Rule-Failure-Code AVP. This indicates to the SAPC that one or more service data flows in the AF session have been deactivated.
- 16. The SAPC removes the failed PCC rule(s) from the IP-CAN session and removes the affected media components and sub-components from the AF session.
- 17. The SAPC performs reauthorization of the IP-CAN session, as described in Section 4.2 on page 41.
- 18. The SAPC sends a CCA message to the PCEF including the new/modified Policy and Charging Control information
- 20. If not all the service data flows within the AF session are affected and the AF has requested to be notified, SAPC sends an RAR message to the AF, including the Specific Action, the deactivated IP Flows encoded in the Flows AVP and the reason for the failure encoded in the Abort-Cause AVP. The SAPC sets the Specific-Action AVP to INDICATION\_OF\_RELEASE\_OF\_BEARER or INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION according to the notification event the AF has previously subscribed to. The SAPC sets the Abort-Cause AVP to the value BEARER\_RELEASED in all cases except when the Rule-Failure-Code AVP received from the PCEF is set to PS\_TO\_CS\_HANDOVER (see Section 4.4.2 on page 84).
- 23. If all the service data flows within the AF session are deactivated, the SAPC informs the AF by sending an ASR command, including the reason for the failure encoded in the Abort-Cause AVP. The SAPC sets the Abort-Cause AVP to the value BEARER\_RELEASED in all cases except when the Rule-Failure-Code AVP received from the PCEF is set to PS\_TO\_CS\_HANDOVER. The SAPC sends the ASR command in this case regardless of whether the AF has previously subscribed to any notification event.

After sending the ASR command, the SAPC decreases the counter of active AF sessions.

### 4.3.2 Successful Resources Allocation

The following figure shows the signalling flow that takes place for the notification of successful installation of dynamic PCC rules to the AF, and the main actions taken by the SAPC to perform dynamic policy control. A precondition for this use case is that the event-trigger SUCCESSFUL\_RESOURCE\_ALLOCATION is included in the list of events that the SAPC is configured to subscribe to.

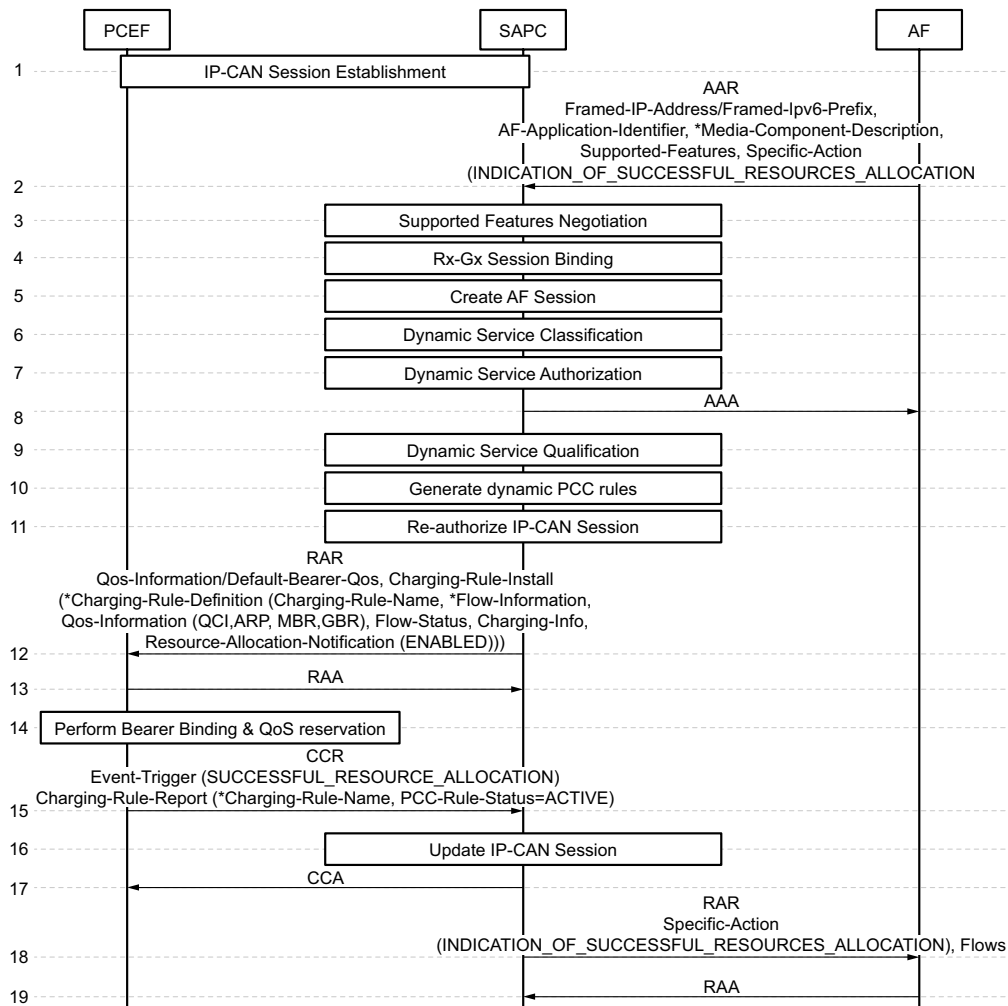


Figure 13 Notification of Successful Resources Allocation to the AF

- Steps 1–14 are similar to the ones explained in section AF Session Establishment. Next, the main differences are highlighted.
- 1. During IP-CAN session establishment, the SAPC provides the Event-Trigger AVP with the value SUCCESSFUL\_RESOURCE\_ALLOCATION.
- 2. In addition to the service information, the SAPC receives the list of bearer events that the AF requests to be notified in the Specific Action AVP, including the value INDICATION\_OF\_SUCCESSFUL\_RESOURCES\_ALLOCATION.
- 12. For each generated dynamic PCC rule, the SAPC includes the Resource-Allocation-Notification AVP set to ENABLED to indicate the PCEF that a confirmation about resource allocation is required.
- 15. The PCEF sends a CCR-Update with Event-Trigger AVP set to SUCCESSFUL\_RESOURCE\_ALLOCATION, that includes a Charging-Rule-Report AVP with the PCC-Rule-Status AVP set to



the value ACTIVE, and the list of PCC rules that have been successfully installed/activated.

- 16. The SAPC updates the IP-CAN session and identifies the affected PCC rule(s) and the corresponding AF media components.
- 17. The SAPC accepts the notification.

**Note:** Reception of a CCR command that includes only Event-Trigger AVP set to SUCCESSFUL\_RESOURCE\_ALLOCATION, does not trigger a policy re-evaluation at the SAPC.

- 18. The SAPC sends an RAR command to the AF with Specific-Action AVP set to the value INDICATION\_OF\_SUCCESSFUL\_RESOURCES\_ALLOCATION and the affected IP Flows encoded in the Flows AVP
- 19. The AF accepts the notification.

### 4.3.3

#### Network Location Information (NetLoc)

The Network Location Information (NetLoc) is an optional function.



## 4.3.3.1

## AF Session Creation or Modification to Add a Media Component



Figure 14 Network Location Information during AF Session Creation or Modification to Add a Media Component

## AF Session Creation

- 2. The SAPC receives a Gx CCR-Initial command from the PCEF indicating an IP-CAN session establishment, which includes the Supported-Features AVP with the NetLoc bit set.



- 3. The SAPC authorizes the IP-CAN session.
- 4. If the corresponding license for Netloc is active, the SAPC sends a CCA-Initial command to the PCEF including the Supported-Features AVP with the NetLoc bit set and the Event-Trigger AVP with ACCESS\_NETWORK\_INFO\_REPORT (45) (if this event is configured).  
  
**Note:** If the corresponding license for Netloc is not active, the SAPC accepts IP-CAN session establishment and ignores the Netloc feature bit in Supported-Features AVP.
- 5. The AF requires the SAPC for the access network information (user location or MS timezone, or both) at the AF session establishment.
- 6. The AF sends an AAR command to the SAPC including the Supported-Features AVP with the NetLoc bit set, the Specific-Action AVP with the value ACCESS\_NETWORK\_INFO\_REPORT, and the Required-Access-Info AVP with the required access network information (USER\_LOCATION (0) or MS\_TIME\_ZONE (1)). Two instances of Required-Access-Info AVP are received in case both information types are required.
- 7. The SAPC creates the AF session and binds the AF session with the existing IP-CAN session.
- 8. The SAPC identifies the service corresponding to the AF session by performing the service classification and performs the service authorization of the previously identified service.
- 9. The SAPC sends an AAA command through the Rx interface including the Result-Code parameter with the value "SUCCESS" (code 2001) and the Supported-Features AVP with the NetLoc bit set. If the PCEF does not support the Network Location Information function, the following steps are not performed. For detailed information, see Section 4.3.3.6.1 on page 57.
- 10. The SAPC performs the dynamic service qualification to generate, for example, the QoS information that applies to the PCC rules.
- 11. The SAPC generates the PCC rules including Network Location Information required by the AF, if the PCEF supports the NetLoc function.
- 12. The SAPC sends an RAR command including the Required-Access-Info AVP inside the Charging-Rule-Definition AVP to the PCEF to request for the access network information, either with USER\_LOCATION (0) or MS\_TIME\_ZONE (1) value. Two instances of Required-Access-Info AVP are included in case both information type is required by the AF. Message also includes the Event-Trigger AVP with ACCESS\_NETWORK\_INFO\_REPORT (45) if this event trigger has not been sent before for this IP-CAN session.
- 13. The PCEF accepts the installation of PCC rules and sends an RAA command in response.
- 14. The PCEF performs bearer binding.



- 15. The PCEF retrieves location information from the network.
- 16. The PCEF sends a CCR-Update command to the SAPC to report the access network information including the Event Trigger (ACCESS\_NETWORK\_INFO\_REPORT), the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (only used if 3GPP-User-Location-Info AVP is not available), and/or the 3GPP-MS-TimeZone AVP (if available).

**Note:** When the CCR-Update command includes only this Event Trigger, the IP-CAN session is not reauthorized.

- 17. The SAPC sends a CCA-Update command to the PCEF in response.
- 18. The SAPC determines to report the network information received to the AFs which requested NetLoc.

One CCR-U with Netloc may cause multiple Rx RARs towards all AFs which requested Netloc for that IP-CAN session.

- 19. The SAPC sends an RAR command to the AF to report the requested access network information by including the 3GPP-User-Location-Info AVP (if available), the 3GPP-MS-TimeZone AVP (if available), and the 3GPP-SGSN-MCC-MNC AVP (if 3GPP-User-Location-Info AVP is not available) and the Specific-Action AVP set to ACCESS\_NETWORK\_INFO\_REPORT.

If the SAPC receives several CCR-U commands with the ACCESS\_NETWORK\_INFO\_REPORT event trigger, for example one CCR-U for each PCC rule sent in previous Gx RAR, the first CCR-U with NetLoc information provokes RARs to all the AFs having requested NetLoc.

- 20. The AF sends an RAA command to the SAPC including the Result-Code parameter with the value "SUCCESS" (code 2001).

#### **AF Session Modification to Add a Media Component or for Gating**

- 22. The AF requires the SAPC for the access network information (user location or MS timezone, or both) at the AF session modification to add a media component.
- 23. The AF sends an AAR command to the SAPC, including the Specific-Action AVP with the value ACCESS\_NETWORK\_INFO\_REPORT and the Required-Access-Info AVP with the required access network information (USER\_LOCATION (0) or MS\_TIME\_ZONE (1)). Two instances of Required-Access-Info AVP are received in case both information types are required.
- 24. The SAPC accepts the message with an AAA command.
- The use case follows as described from step 10 to 20.



**Note:** The NetLoc request applies to all the new and updated PCC rules. If it is an AF session modification for gating, NetLoc is requested for the modified PCC rules.

#### 4.3.3.2

#### AF Session Modification to Remove a Media Component or Media Subcomponent

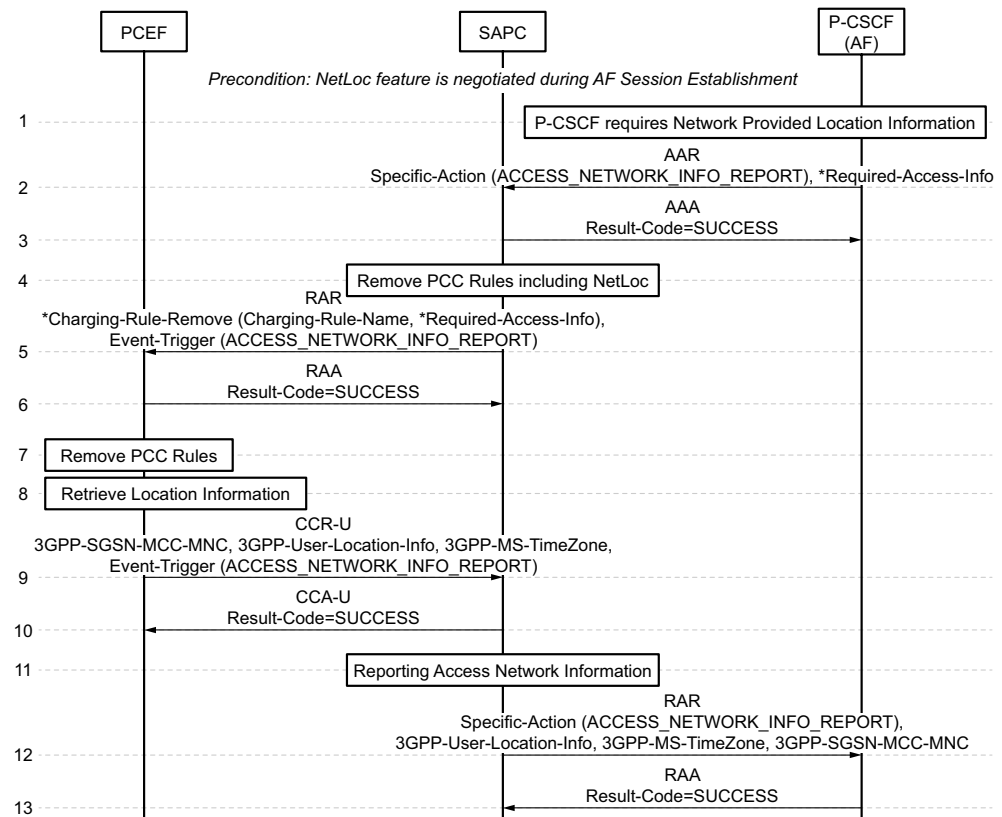


Figure 15 Network Location Information during AF Session Modification to Remove a Media Component or Media Subcomponent

The precondition is that the NetLoc function is negotiated during IP-CAN session establishment and AF session establishment.

- 1. The AF requires the SAPC for the access network information (user location or MS timezone, or both) at the AF session modification to remove a media component or a media subcomponent.
- 2. The AF sends an AAR command to the SAPC, including the Specific-Action AVP with the value ACCESS\_NETWORK\_INFO\_REPORT and the Required-Access-Info AVP with the required access network information (USER\_LOCATION (0) or MS\_TIME\_ZONE (1)). Two instances of Required-Access-Info AVP are received in case both information types are required.

- 3. The SAPC sends an AAA command through the Rx interface including the Result-Code parameter with the value "SUCCESS" (code 2001).
- 4. The SAPC removes the PCC rules including Network Location Information.
- 5. The SAPC sends an RAR command including the Required-Access-Info AVP inside the Charging-Rule-Remove AVP to the PCEF to request for the access network information, either with USER\_LOCATION (0) or MS\_TIME\_ZONE (1) value. Two instances of Required-Access-Info AVP are included in case both information types are required by the AF. Message also includes the Event-Trigger AVP with ACCESS\_NETWORK\_INFO\_REPORT (45) if this event trigger has not been sent before for this IP-CAN session.
- 6. The PCEF accepts the message with an RAA command.
- 7. The PCEF removes the PCC rules.
- 8-13. Same to step 15-20 of Section 4.3.3.1 on page 47.

### 4.3.3.3

### AF Session Termination

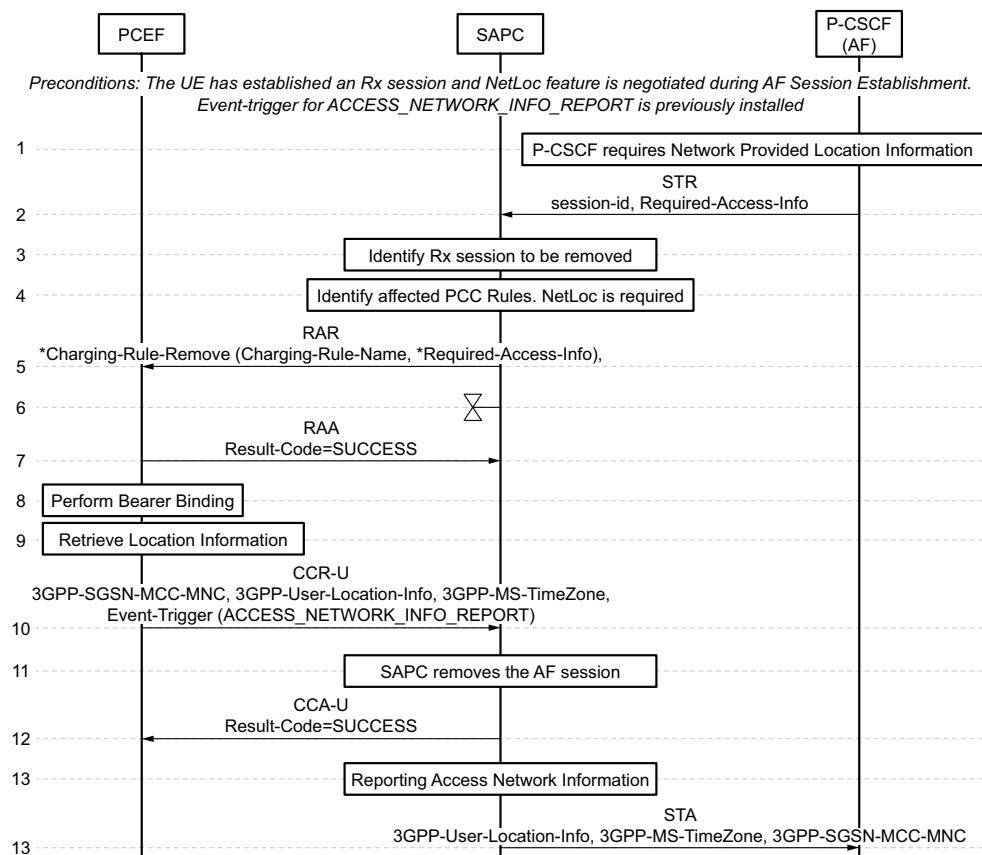


Figure 16 Network Location Information during AF Session Termination





- 1 The AF requires the SAPC for the access network information (user location or MS timezone, or both) at the AF session termination.
- 2 The AF sends an STR command to indicate the termination of the AF session. The STR command includes the Required-Access-Info AVP with the required access network information (USER\_LOCATION (0) or MS\_TIME\_ZONE (1)). Two instances of Required-Access-Info AVP are received in case both information types are required.
- 3 The SAPC identifies the session to be removed.
- 4 The SAPC identifies affected PCC rules.
- 5 The SAPC sends an RAR command including the Required-Access-Info AVP inside the Charging-Rule-Remove AVP to the PCEF to request for the access network information, either with USER\_LOCATION (0) or MS\_TIME\_ZONE (1) value. Two instances of Required-Access-Info AVP are received in case both information types are required. Message also includes the Event-Trigger AVP with ACCESS\_NETWORK\_INFO\_REPORT (45) if this event trigger has not been sent before for this IP-CAN session.
- 6 The SAPC starts a timer to wait for CCR-Update with access network information. The default value of the timer is 3 seconds.
 

**Note:** If the timer expires before the SAPC receives CCR-U with access network information, the SAPC returns STA to the AF without any access network information and logs WARNING condition. Otherwise, the timer ends after sending STA message.
- 7 The PCEF accepts the removal of the PCC rules with an RAA answer.
- 8 The PCEF performs bearer binding.
- 9 The PCEF retrieves the location information.
- 10 The PCEF sends a CCR-U command to the SAPC to report the access network information including the Event Trigger (ACCESS\_NETWORK\_INFO\_REPORT), the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (only used if 3GPP-User-Location-Info AVP is not available), and/or the 3GPP-MS-TimeZone AVP (if available).
 

**Note:** When the CCR-Update command includes only this Event Trigger, the IP-CAN session is not reauthorized.
- 11 The SAPC removes the AF session.
- 12 The SAPC accepts the CCR-U with CCA-U.
- 13 The SAPC determines to report the network information received to the AF which requested NetLoc.

- 14 The SAPC sends an STA command to the AF with the requested access network information including the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (if 3GPP-User-Location-Info AVP is not available), and/or the 3GPP-MS-TimeZone AVP (if available).

The preconditions are that the UE has established an AF session and the NetLoc function is negotiated during the AF session establishment.

#### 4.3.3.4

#### IP-CAN Session Termination

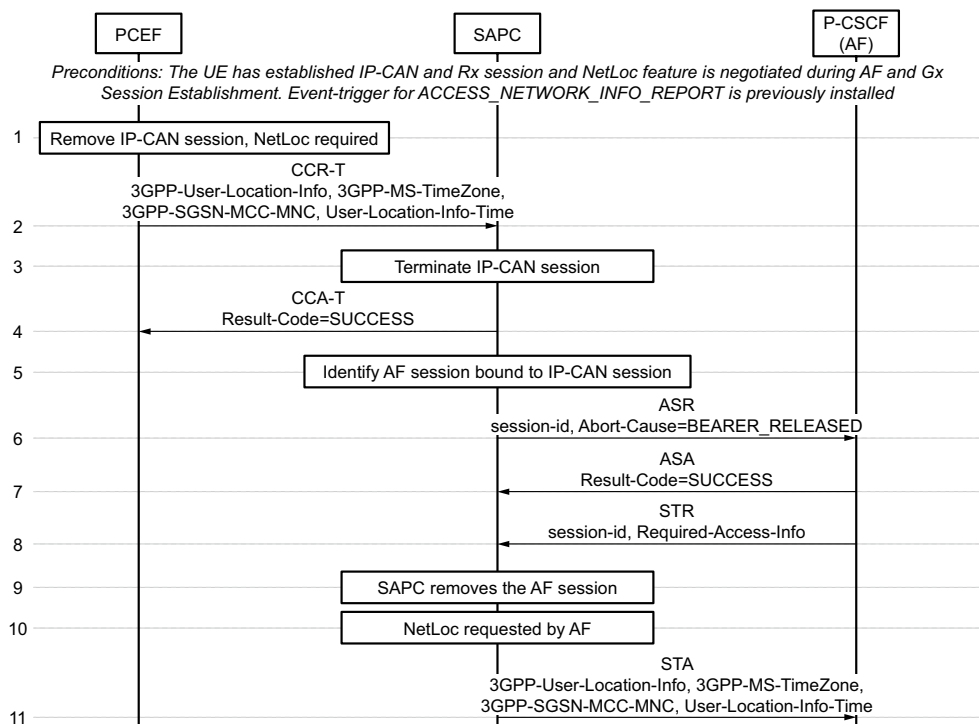


Figure 17 Network Location Information during IP-CAN Session Termination

- 1 The PCEF removes the IP-CAN session and retrieves the Network Location Information.
- 2 The PCEF sends a CCR-Terminate command with the access network information including the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (if 3GPP-User-Location-Info AVP is not available), the User-Location-Info-Time AVP (if available), and/or the 3GPP-MS-TimeZone AVP (if available).
- 3 The SAPC terminates the IP-CAN session.
- 4 The SAPC sends the CCA-Terminate answer to the PCEF, including the Result-Code parameter with the value "SUCCESS" (code 2001).
- 5 The SAPC identifies the AF sessions bound to the IP-CAN session.



- 6 The SAPC sends an ASR command for each bound AF session , including the Abort-Cause AVP set to BEARER\_RELEASED.
- 7 The AF answers with an ASA message.
- 8 The AF sends an STR command to request the termination of the AF session. The STR command includes the Required-Access-Info AVP with the required access network information (USER\_LOCATION (0) or MS\_TIME\_ZONE (1)). Two instances of Required-Access-Info AVP are received in case both information types are required.
- 9 The SAPC removes the AF session.
- 10 The SAPC determines to report the network information received to the AF which requested NetLoc.
- 11 The SAPC sends an STA command to the AF with the requested access network Information including the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (if 3GPP-User-Location-Info AVP is not available), the User-Location-Info-Time AVP (if available), and/or the 3GPP-MS-TimeZone AVP (if available).

### 4.3.3.5 IP-CAN Bearer Release

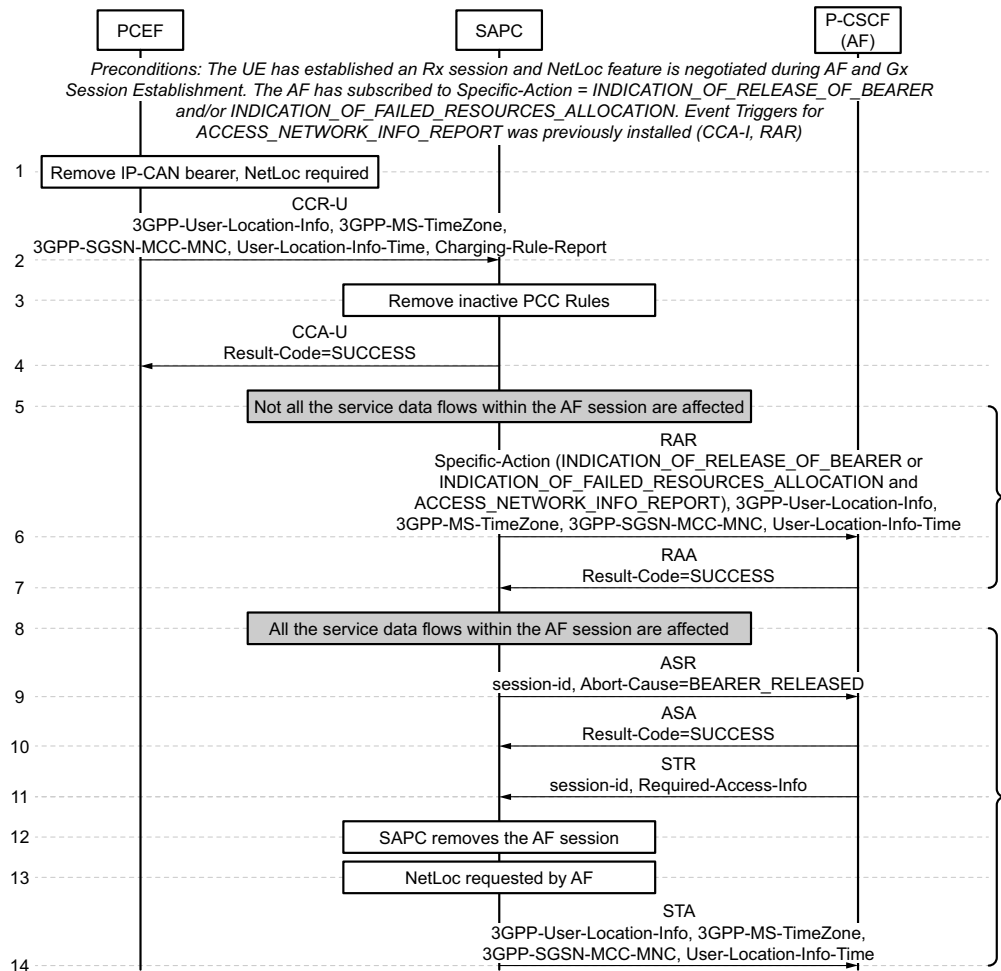


Figure 18 Network Location Information during IP-CAN Bearer Release

- 1. The PCEF removes the IP-CAN bearer and retrieves the Network Location Information.
- 2. The PCEF sends a CCR-U command to the SAPC with the access network information including the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (only used if 3GPP-User-Location-Info AVP is not available), the User-Location-Info-Time AVP (if available), and/or the 3GPP-MS-TimeZone AVP (if available), and Charging-Rule-Report AVP.
- 3. The SAPC removes inactive PCC rules.
- 4. The SAPC sends a CCA-U answer to the PCEF.
- 5-7. If not all the service data flows within AF session are affected, the SAPC sends an RAR command to the AF to report the access network information including the 3GPP-User-Location-Info AVP (if available) or the 3GPP-SGSN-MCC-MNC AVP (if 3GPP-User-Location-Info



AVP is not available), the User-Location-Info-Time AVP (if available), the 3GPP-MS-TimeZone AVP (if available), and the Specific-Action AVPs set to INDICATION\_OF\_RELEASE\_OF\_BEARER or INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION and also set to ACCESS\_NETWORK\_INFO\_REPORT.

- 8-16. If all the service data flows within AF session are affected, the steps are the same to step 6-11 of Section 4.3.3.4 on page 54.

### 4.3.3.6 Failure Handling of AF Session Creation or Modification

#### 4.3.3.6.1 Failure Handling when the PCEF does not Support NetLoc

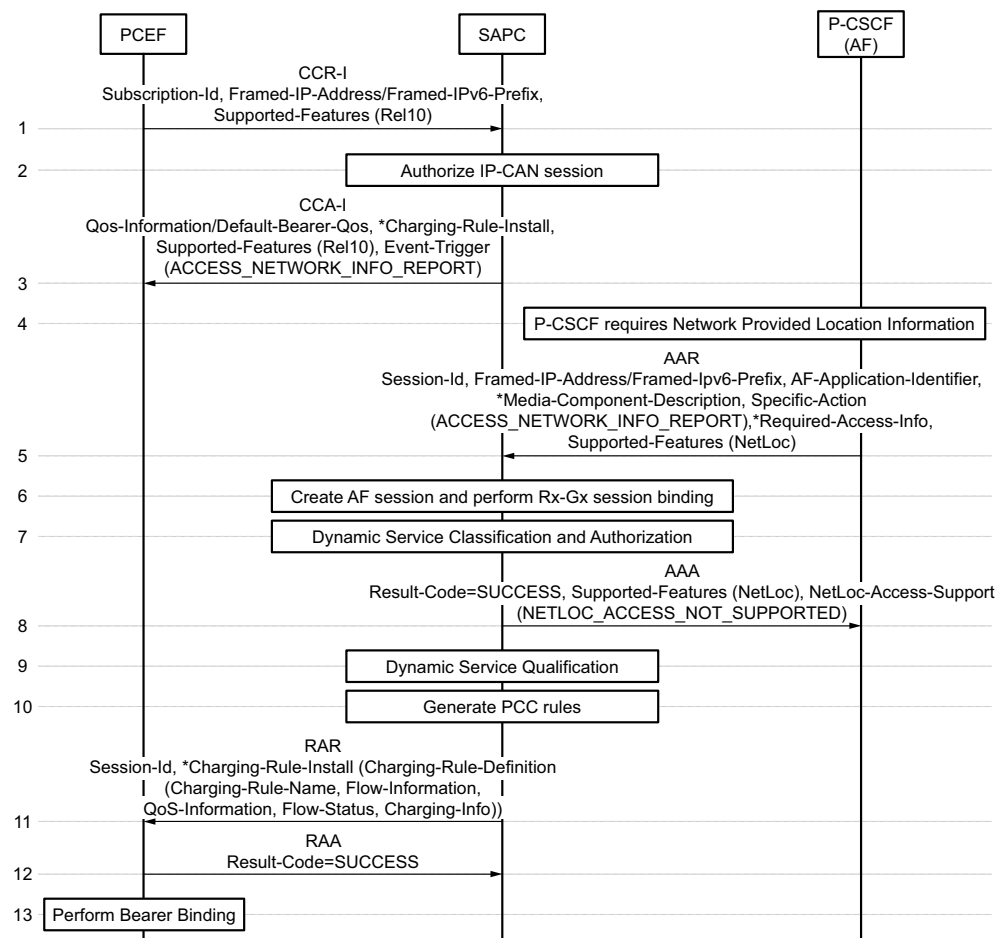


Figure 19 Failure Handling when the PCEF does not Support NetLoc

- 1 The SAPC receives a Gx CCR-Initial command from the PCEF indicating an IP-CAN session establishment without including the NetLoc feature bit set in the Supported-Features AVP.
- 2 The SAPC authorizes the IP-CAN session.



- 3 The SAPC accepts IP-CAN session establishment including the Supported-Features AVP without the NetLoc bit set, and the Event-Trigger AVP with ACCESS\_NETWORK\_INFO\_REPORT (45) (if this event is configured).
- 4 The AF requires the SAPC for the access network information (user location or MS timezone, or both) at the AF session establishment.
- 5 The AF sends an AAR command to the SAPC including the Supported Features AVP with the NetLoc bit set, the Specific-Action AVP with the value ACCESS\_NETWORK\_INFO\_REPORT, and the Required-Access-Info AVP with the required access network information.
- 6 The SAPC creates the AF session and binds the AF session with the existing IP-CAN session.
- 7 The SAPC identifies the service corresponding to the AF session by performing the service classification and performs the service authorization of the previously identified service.
- 8 Because the PCEF does not support the NetLoc function, the SAPC sends an AAA command to the AF including a NetLoc-Access-Support AVP with the value of 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED) through the Rx interface. The NetLoc bit in the Supported Features AVP is set.
- 9 The SAPC performs the dynamic service qualification to generate, for example, the QoS information that applies to the PCC rules.
- 10 The SAPC generates the PCC rules.
- 11 Because the PCEF does not support the NetLoc function, the SAPC sends an RAR command and the Charging-Rule-Install AVP to the PCEF to install the PCC rules, without the Required-Access-Info AVP within the Charging-Rule-Definition AVP.
- 12 The PCEF accepts the installation of PCC rules and sends an RAA command in response.
- 13 The PCEF performs bearer binding.



## 4.3.3.6.2

## Failure Handling when the IP-CAN Session does not Support NetLoc

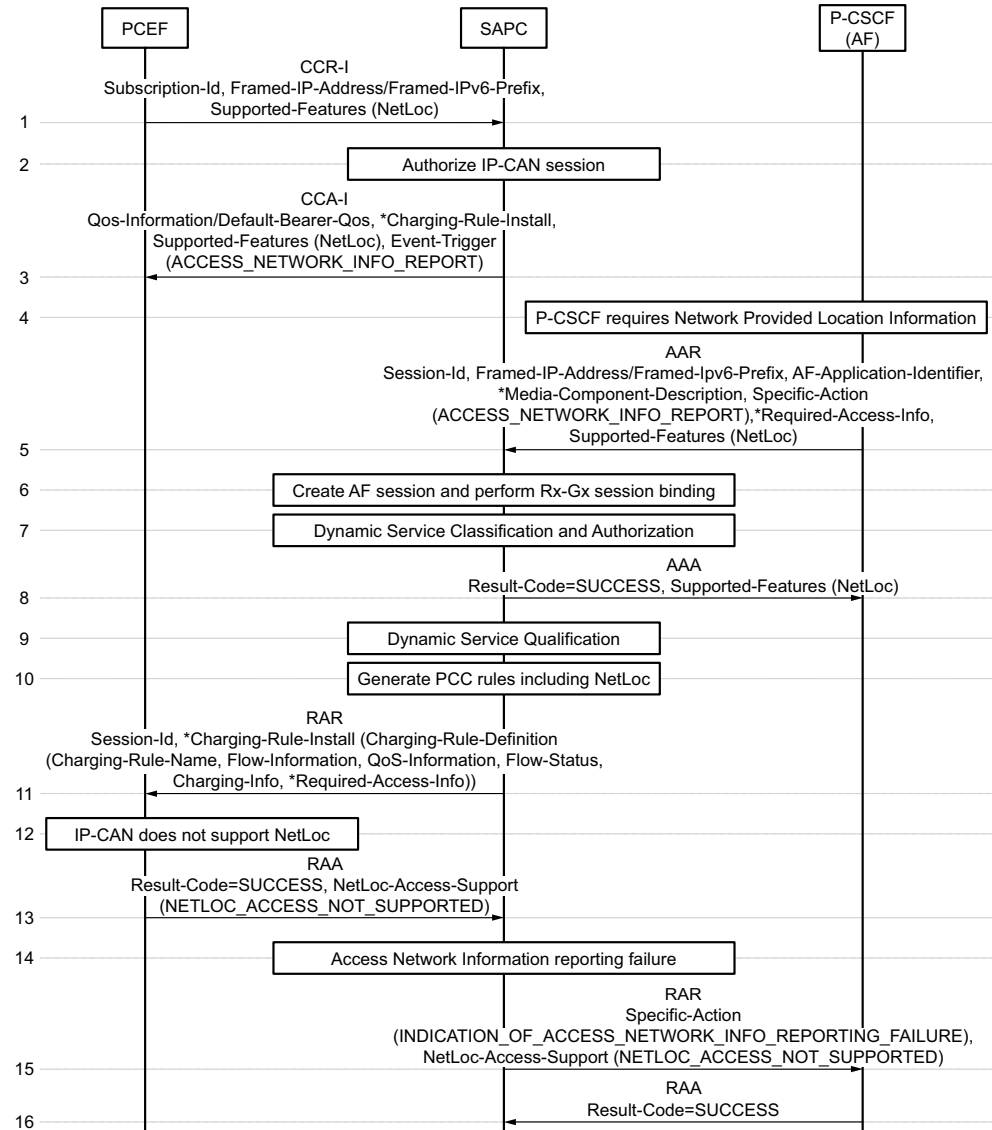


Figure 20 Failure Handling when the IP-CAN Session does not Support NetLoc

- 1-11. Same to step 1-12 of Section 4.3.3.1 on page 47.
- 12. The access network currently serving the UE does not support access network information retrieval.
- 13. The PCEF sends an RAA command to the SAPC including the NetLoc-Access-Support AVP with the value of 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED).
- 14. The SAPC considers this situation as an Access Network Information Reporting failure.

- 15. The SAPC sends an RAR command to the AF including Specific-Action AVP set to INDICATION\_OF\_ACCESS\_NETWORK\_INFO\_REPORTING\_FAILURE and the NetLoc-Access-Support AVP with value 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED) as failure reason.
- 16. The AF sends an RAA command to the SAPC including the Result-Code parameter with the value "SUCCESS" (code 2001).

### 4.3.3.7 Failure Handling of AF Session Termination

#### 4.3.3.7.1 Failure Handling when the PCEF does not Support NetLoc

This use case is similar to the AF Session Creation in Section 4.3.3.6.1 on page 57, but with the following difference:

During AF session termination, the SAPC answers with an STA command to the AF including the NetLoc-Access-Support AVP with value 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED) as failure reason. For the AF session termination procedure, see Section 4.3.3.3 on page 52.

#### 4.3.3.7.2 Failure Handling when the IP-CAN Session does not Support NetLoc

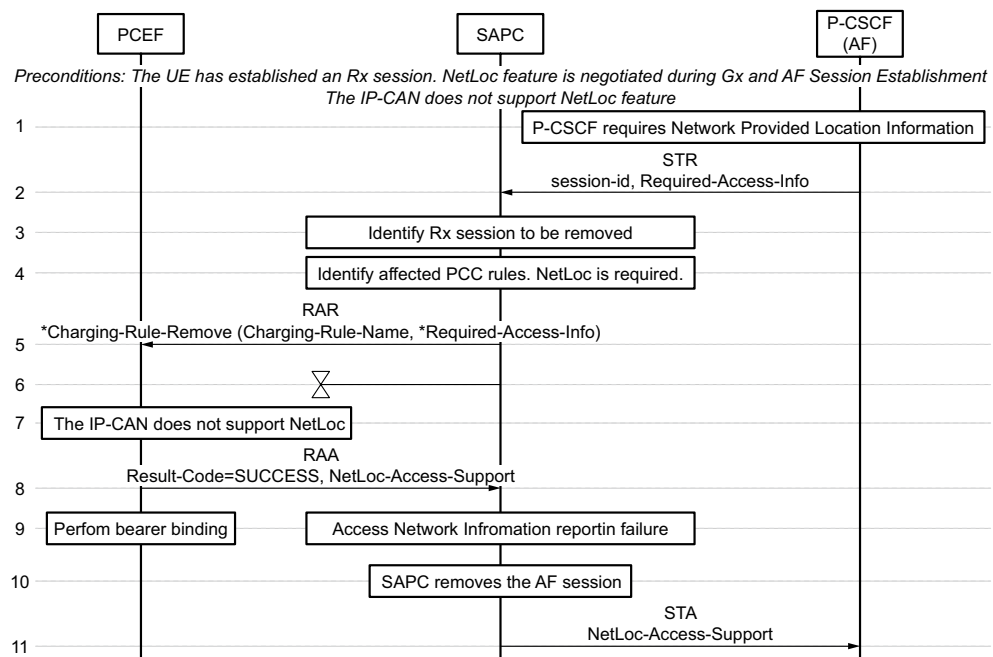


Figure 21 Failure Handling of AF Session Termination when the IP-CAN Session does not Support NetLoc

- Step 1-5. Same to step 1-5 of Section 4.3.3.3 on page 52.
- 6. The access network currently serving the UE does not support access network information retrieval.





- 7. The PCEF accepts the removal of PCC rules and sends an RAA command in response. The RAA command includes the NetLoc-Access-Support AVP set to the value of 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED) and the Result-Code parameter with the value "SUCCESS" (code 2001).
- 8. The SAPC considers the situation as an access network information reporting failure.
- 9. The SAPC removes the AF session.
- 10. The SAPC sends an STA command to the AF including a NetLoc-Access-Support AVP with the value of 0 (NETLOC\_ACCESS\_NOT\_SUPPORTED).

#### 4.3.4

#### Network Location Information (NetLoc) in Untrusted WLAN Access

The Network Location Information (NetLoc) in Untrusted WLAN Access is an optional function.

#### 4.3.4.1

#### AF Session Creation or Modification to Add a Media Component

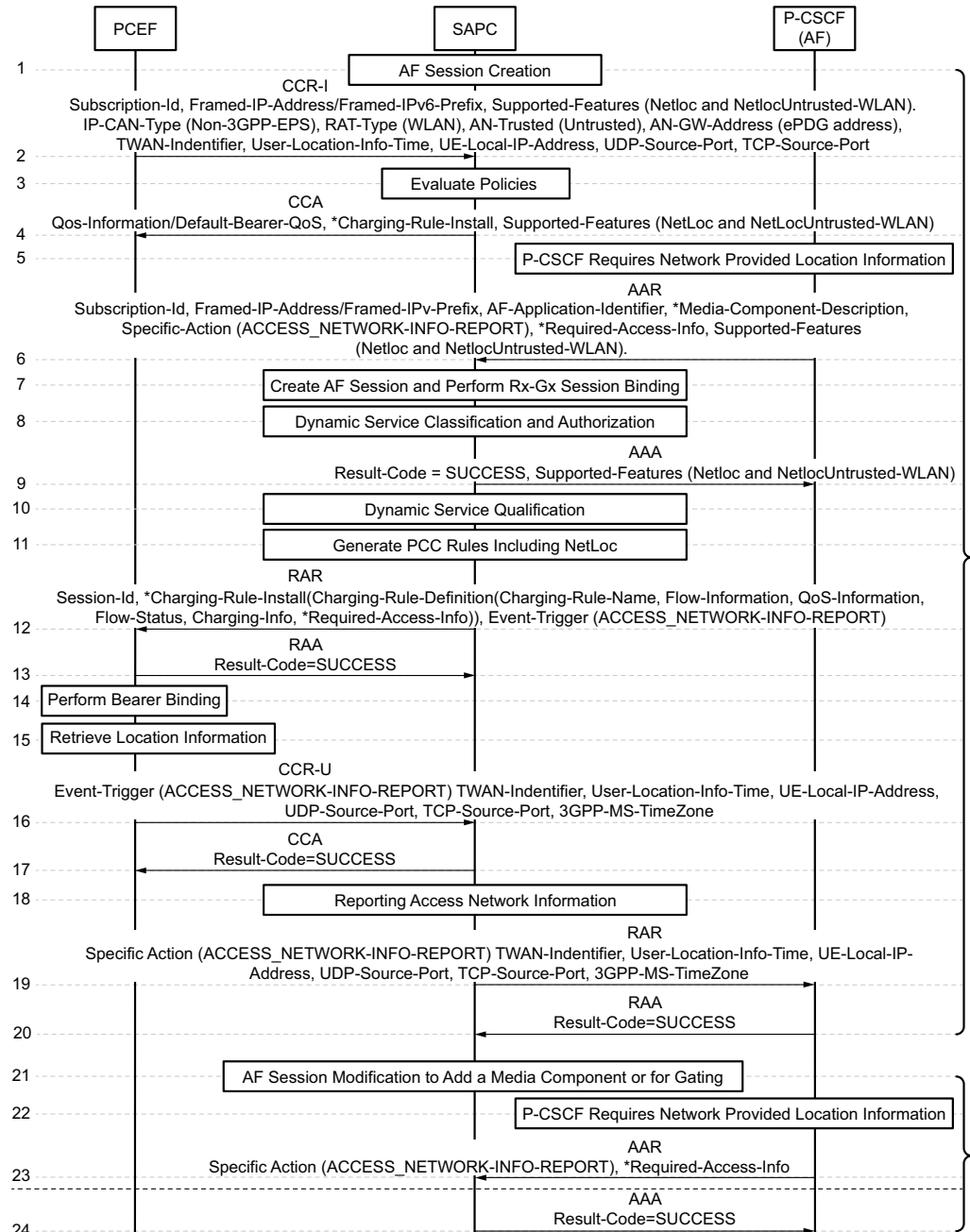


Figure 22 Network Location Information in Untrusted WLAN Access during AF Session Creation or Modification to Add a Media Component

#### AF Session Creation

- 2. The SAPC receives a Gx CCR-Initial command from the PCEF indicating an IP-CAN session establishment, which includes:



- Supported-Features AVP with the NetLoc and NetlocUntrusted-WLAN bits set.
  - IP-CAN-Type AVP= Non-3GPP-EPS (6)
  - RAT-Type AVP= WLAN (0)
  - AN-Trusted AVP = UNTRUSTED (1)
  - AN-GW-Address (ePDG IP address used as IPSec tunnel endpoint with the UE)
  - 3GPP-SGSN-MCC-MNC (Serving Network Identifier)
  - TWAN-Identifier (optional, UE location in WLAN access)
  - User-Location-Info-Time (optional, NTP at which the UE was known to be at the location)
  - UE-Local-IP-Address (optional, may be IPv4 or IPv6)
  - UDP-Source-Port (optional, UDP source port number used for the IKEv2 tunnel in the case that a NAT is detected)
  - TCP-Source-Port (optional, TCP source port number used for the IKEv2 tunnel in the case that a NAT and firewall are detected)
  - 3GPP-MS-Timezone (optional)
- 3. The SAPC authorizes the IP-CAN session and evaluate policies.
- 4. If the corresponding license for Netloc is active, the SAPC sends a CCA-Initial command to the PCEF including the Supported-Features AVP with the NetLoc and NetlocUntrusted-WLAN bits set.
- Note:** If the corresponding license for Netloc is not active, the SAPC accepts IP-CAN session establishment and ignores the Netloc and NetlocUntrusted-WLAN feature bits in Supported-Features AVP.
- Steps 5-15. Same to steps 5-15 of Section 4.3.3.1 on page 47 but with the following differences:
- AAR command from the AF to the SAPC includes the Supported-Features AVP with the Netloc and NetlocUntrusted-WLAN feature bits set.
  - AAA command from the SAPC to the AF includes the Supported-Features AVP with the Netloc and NetlocUntrusted-WLAN feature bits set.
- 16. The PCEF sends a CCR-Update command to the SAPC to report the access network information including the Event Trigger ACCESS\_NETWORK\_INFO\_REPORT and the following AVPs if the user location information was requested by the SAPC and was provided to the PCEF:

- The UE local IP address (may be IPv4 or IPv6) within the UE-Local-IP-Address AVP
- The UDP source port number (used for the IKEv2 tunnel in the case that a NAT is detected) within the UDP-Source-Port AVP
- The TCP source port number (used for the IKEv2 tunnel in the case that a NAT and firewall are detected) within the TCP-Source-Port AVP
- WLAN location information within the TWAN-Identifier AVP (if received from ePDG)
- Location timestamp in the User-Location-Info-Time AVP (NTP at which the UE was known to be at the location)
- The Serving Network of the ePDG in 3GPP-SGSN-MCC-MNC AVP (If the user location information was requested by the SAPC and the PCEF does not receive user location information from the ePDG)

If the time zone was requested by the SAPC, it also includes:

- 3GPP- MS-Timezone AVP

**Note:** When the CCR-Update command includes only this Event Trigger, the IP-CAN session is not reauthorized.

- 17. The SAPC sends a CCA-Update command to the PCEF in response.
- 18. The SAPC determines to report the network information received to the AFs which requested NetLoc.

One CCR-U with Netloc may cause multiple Rx RARs towards all AFs which requested Netloc for that IP-CAN session.

- 19. The SAPC sends an RAR command to the AF to report the requested access network information by including the UE-Local-IP-Address AVP (if available), the UDP-Source-Port AVP (if available), the TCP-Source-Port AVP (if available), the TWAN-Identifier AVP (if available), the User-Location-Info-Time AVP (if available), the 3GPP-SGSN-MCC-MNC AVP (if available), the 3GPP-3GPP-MS-TimeZone AVP (if available) and the Specific-Action AVP set to ACCESS\_NETWORK\_INFO\_REPORT.

If the SAPC receives several CCR-U commands with the ACCESS\_NETWORK\_INFO\_REPORT event trigger, for example one CCR-U for each PCC rule sent in previous Gx RAR, the first CCR-U with NetLoc information provokes RARs to all the AFs having requested NetLoc.

- Steps 20-24 Same to steps 20-24 of Section 4.3.3.1 on page 47.



## 4.3.4.2

## AF Session Modification to Remove a Media Component or Media Subcomponent

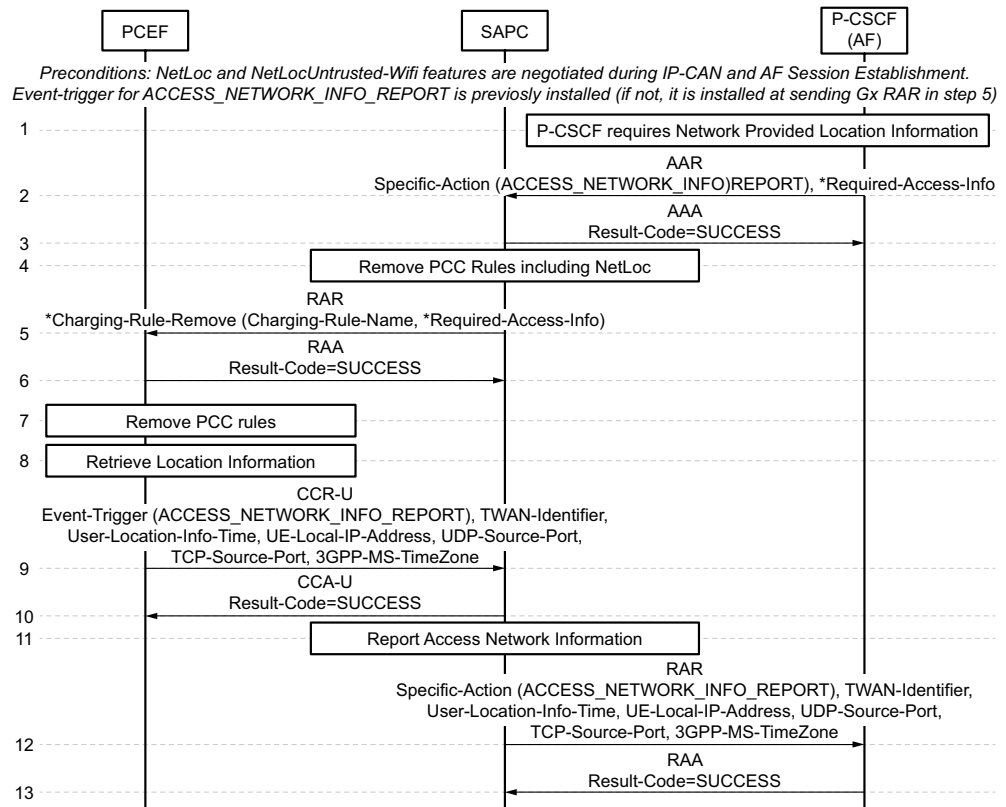


Figure 23 Network Location Information in Untrusted WLAN Access during AF Session Modification to Remove a Media Component or Media Subcomponent

The precondition is that the NetLoc and NetLocUntrusted-WLAN features are negotiated during IP-CAN session establishment and AF session establishment.

Steps are explained in Section 4.3.3.2 on page 51 but steps 8-13 are same as steps 15-20 of Section 4.3.4.1 on page 61.

### 4.3.4.3 AF Session Termination

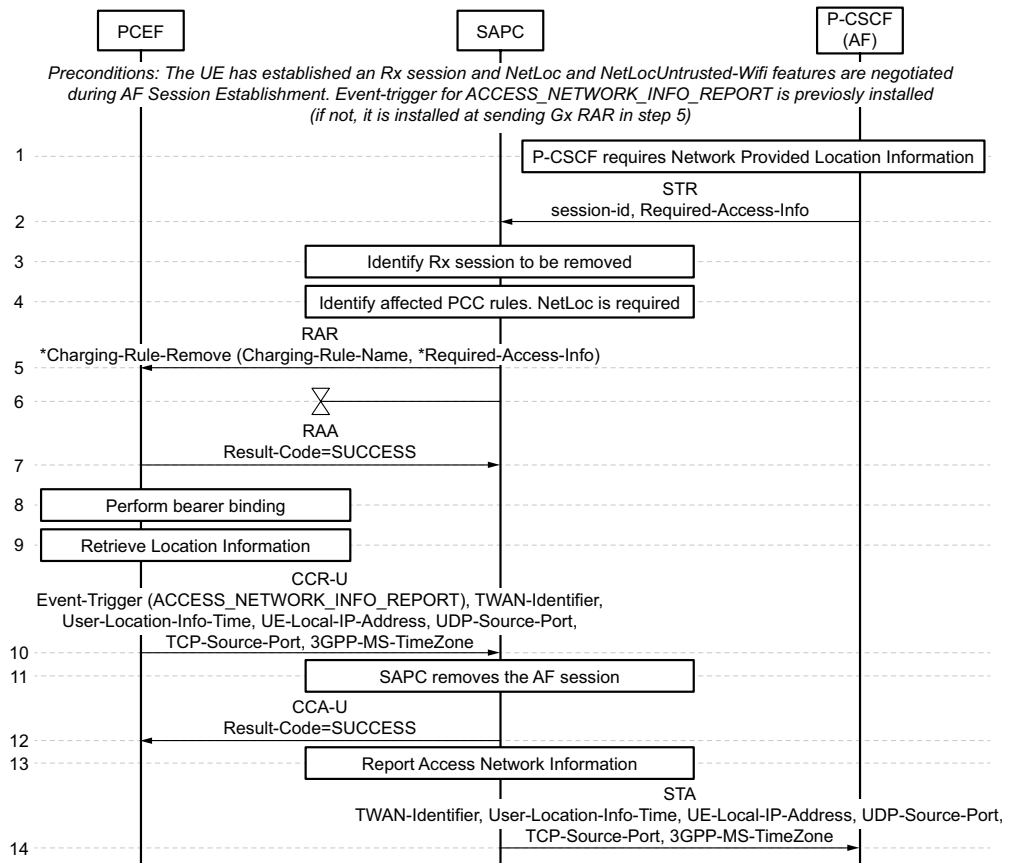


Figure 24 Network Location Information in Untrusted WLAN Access during AF Session Termination

The preconditions are that the UE has established an AF session and the NetLoc and NetLocUntrusted-WLAN features are negotiated during the Gx and Rx session establishment.

Steps are explained in Section 4.3.3.3 on page 52 but with the following differences:

- 10. The PCEF sends a CCR-Update command to the SAPC to report the access network information including:
  - The Event Trigger ACCESS\_NETWORK\_INFO\_REPORT,
  - The UE local IP address (may be IPv4 or IPv6) within the UE-Local-IP-Address AVP (If the user location information was requested by the SAPC and was provided to the PCEF)
  - Optionally, the UDP source port number (used for the IKEv2 tunnel in the case that a NAT is detected) within the UDP-Source-Port AVP or



- The TCP source port number (used for the IKEv2 tunnel in the case that a NAT and firewall are detected) within the TCP-Source-Port AVP
- WLAN location information within the TWAN-Identifier AVP (if received from ePDG)
- Location timestamp in the User-Location-Info-Time AVP (NTP at which the UE was known to be at the location)
- The Serving Network of the ePDG in 3GPP-SGSN-MCC-MNC AVP (If the user location information was requested by the SAPC and the PCEF does not receive user location information from the ePDG)
- 3GPP- MS-Timezone AVP (if the time zone was requested by the SAPC)

**Note:** When the CCR-Update command includes only this Event Trigger, the IP-CAN session is not reauthorized.

- 14. The SAPC sends an STA command to the AF to report the requested access network information by including the UE-Local-IP-Address AVP (if available), the UDP-Source-Port AVP (if available), the TCP-Source-Port AVP (if available), the TWAN-Identifier AVP (if available), the User-Location-Info-Time AVP (if available), the 3GPP-SGSN-MCC-MNC AVP (if available) and the 3GPP-3GPP-MS-TimeZone AVP (if available).

#### 4.3.4.4 IP-CAN Session Termination

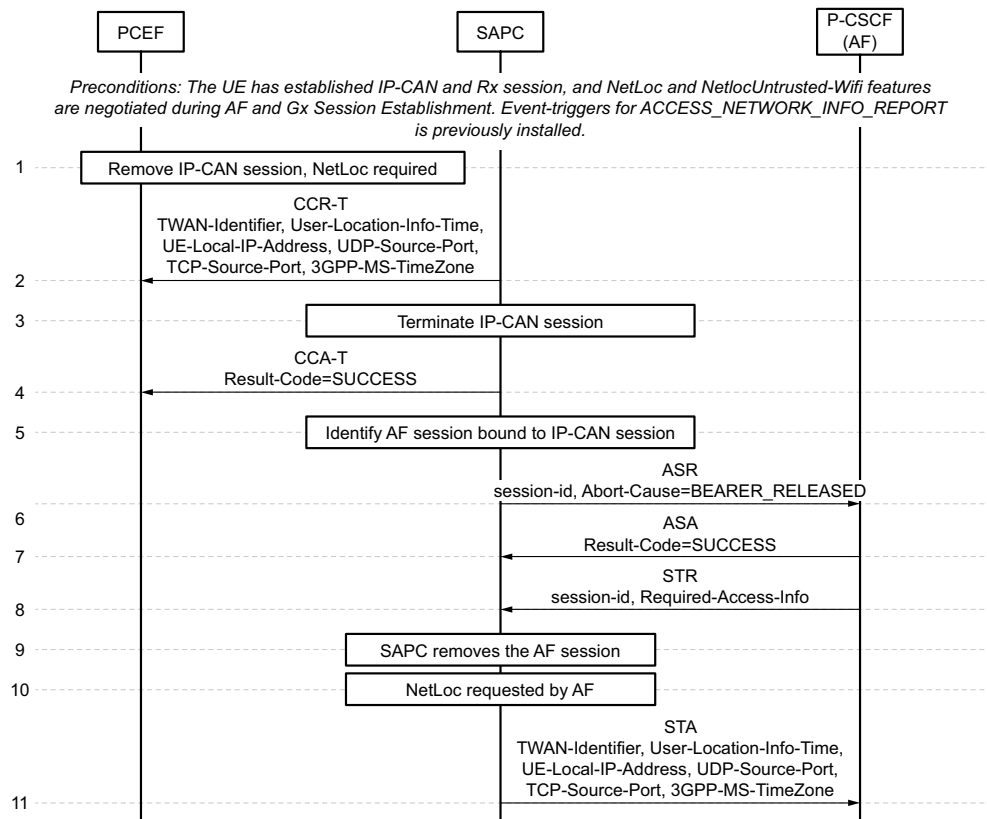


Figure 25 Network Location Information in Untrusted WLAN Access during IP-CAN Session Termination

The preconditions are that the UE has established an AF session, the NetLoc and NetLocUntrusted-WLAN features are negotiated during the AF session establishment and event trigger ACCESS\_NETWORK\_INFO\_REPORT was previously sent during IP-CAN session lifetime.

Steps are explained in Section 4.3.3.4 on page 54 but with the following differences:

- 2. The PCEF sends a CCR-Termination command to the SAPC that may include:
  - The UE local IP address (may be IPv4 or IPv6) within the UE-Local-IP-Address AVP
  - Optionally, the UDP source port number (used for the IKEv2 tunnel in the case that a NAT is detected) within the UDP-Source-Port AVP or
  - The TCP source port number (used for the IKEv2 tunnel in the case that a NAT and firewall are detected) within the TCP-Source-Port AVP





- WLAN location information within the TWAN-Identifier AVP (if received from ePDG)
  - Location timestamp in the User-Location-Info-Time AVP (NTP at which the UE was known to be at the location)
  - The Serving Network of the ePDG in 3GPP-SGSN-MCC-MNC AVP (If the PCEF does not receive user location information from the ePDG)
  - 3GPP- MS-Timezone AVP
- 11. The SAPC sends an STA command to the AF to report the access network information by including the UE-Local-IP-Address AVP (if available), the UDP-Source-Port AVP (if available), the TCP-Source-Port AVP (if available), the TWAN-Identifier AVP (if available), the User-Location-Info-Time AVP (if available), the 3GPP-SGSN-MCC-MNC AVP (if available) and the 3GPP-3GPP-MS-TimeZone AVP (if available).
- Note:** If the NetlocUntrusted-WLAN feature has not been negotiated at AF session establishment, the SAPC does not include Untrusted WLAN access network information in Rx STA message.

### 4.3.4.5 IP-CAN Bearer Release

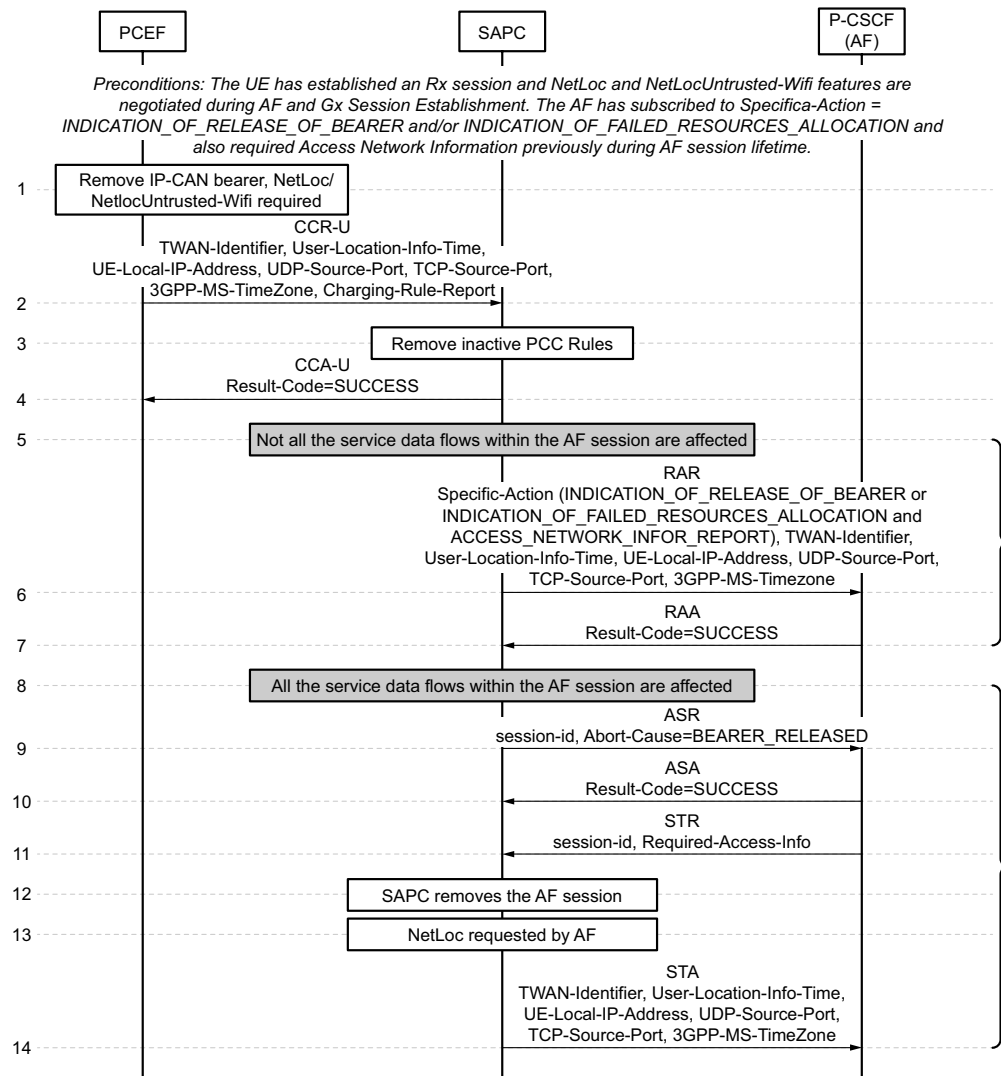


Figure 26 Network Location Information in Untrusted WLAN Access during IP-CAN Bearer Release

Steps are explained in Section 4.3.3.5 on page 55 but with the following differences:

- 2. The PCEF sends a CCR-Update command to the SAPC that may include:
  - The UE local IP address (may be IPv4 or IPv6) within the UE-Local-IP-Address AVP (If it was provided to the PCEF)
  - Optionally, the UDP source port number (used for the IKEv2 tunnel in the case that a NAT is detected) within the UDP-Source-Port AVP or



- The TCP source port number (used for the IKEv2 tunnel in the case that a NAT and firewall are detected) within the TCP-Source-Port AVP
  - WLAN location information within the TWAN-Identifier AVP (if received from ePDG)
  - Location timestamp in the User-Location-Info-Time AVP (NTP at which the UE was known to be at the location)
  - The Serving Network of the ePDG in 3GPP-SGSN-MCC-MNC AVP (If the PCEF does not receive user location information from the ePDG)
  - 3GPP- MS-Timezone AVP
- 5-7. If not all the service data flows within AF session are affected, the SAPC sends an RAR command to the AF to report the access network information including UE-Local-IP-Address AVP (if available), the UDP-Source-Port AVP (if available), the TCP-Source-Port AVP (if available), the TWAN-Identifier AVP (if available), the User-Location-Info-Time AVP (if available), the 3GPP-SGSN-MCC-MNC AVP (if available) and the 3GPP-3GPP-MS-TimeZone AVP (if available), and the Specific-Action AVPs set to INDICATION\_OF\_RELEASE\_OF\_BEARER or INDICATION\_OF\_FAILED\_RESOURCES\_ALLOCATION and also set to ACCESS\_NETWORK\_INFO\_REPORT.
- Note:** If the NetlocUntrusted-WLAN feature has not been negotiated at AF session establishment, the SAPC does not include Untrusted WLAN access network information in Rx RAR message.
- 8-14. If all the service data flows within AF session are affected, the steps are the same to steps 6-11 of Section 4.3.4.4 on page 67
- Note:** If the NetlocUntrusted-WLAN feature has not been negotiated at AF session establishment, the SAPC does not include Untrusted WLAN access network information in Rx STA message.

#### 4.3.4.6 Failure Handling when the AF Session does not support NetLoc in Untrusted WLAN Access

See sequence diagram of Section 4.3.4.1 on page 61, differences are explained below:

- 1-18. Same to step 1-18 of Section 4.3.4.1 on page 61 but with the following differences:
- Step 6. AAR command includes the Supported-Features AVP with only the Netloc bit set (NetLocUntrusted-WLAN bit is unset)
  - Step 9. AAA command includes the Supported-Features AVP with only the Netloc bit set (NetLocUntrusted-WLAN bit is unset)
- 19. As the location information received from PCEF is from Untrusted WLAN access and the AF does not support NetLocUntrusted-WLAN feature, the

SAPC sends an RAR command to the AF including Specific-Action AVP set to `INDICATION_OF_ACCESS_NETWORK_INFO_REPORTING_FAILURE` and the NetLoc-Access-Support AVP with value 0 (`NETLOC_ACCESS_NOT_SUPPORTED`) as failure reason.

**Note:** If 3GPP-SGSN-MCC-MNC AVP or 3GPP-MS-Timezone AVP is received in CCR Update, this step is not performed, instead step 19 of Section 4.3.4.1 on page 61 is performed, that is, this information is sent towards the AF if at least Netloc feature is negotiated at AF session establishment.

- 20. The AF sends an RAA command to the SAPC including the Result-Code parameter with the value "SUCCESS" (code 2001).

If this failure scenario happens during AF session termination, the SAPC answers with an STA command to the AF including the NetLoc-Access-Support AVP with value 0 (`NETLOC_ACCESS_NOT_SUPPORTED`) as failure reason.

**Note:** If 3GPP-SGSN-MCC-MNC AVP or 3GPP-MS-Timezone AVP is received in CCR Update, this step is not performed, instead step 14 of Section 4.3.3.3 on page 52 is performed, that is, this information is sent towards the AF if at least Netloc feature is negotiated at AF session establishment.

### 4.3.5

#### IP-CAN Type Change Notification

The AF subscribes to IP-CAN type changes as a part of the IMS SIP registration or during the IMS SIP call negotiation. In the first case, the AF does not include any media component in the Rx request.

This following traffic case shows an example of subscription, notification and subscription cancellation of the IP-CAN type changes when `IP-CAN_CHANGE` and `RAT_CHANGE` event triggers are not statically or dynamically provisioned. In the example, the IP-CAN type information changes from "Non-3GPP-EPS" and "WLAN" to "3GPP-EPS" and "EUTRAN".

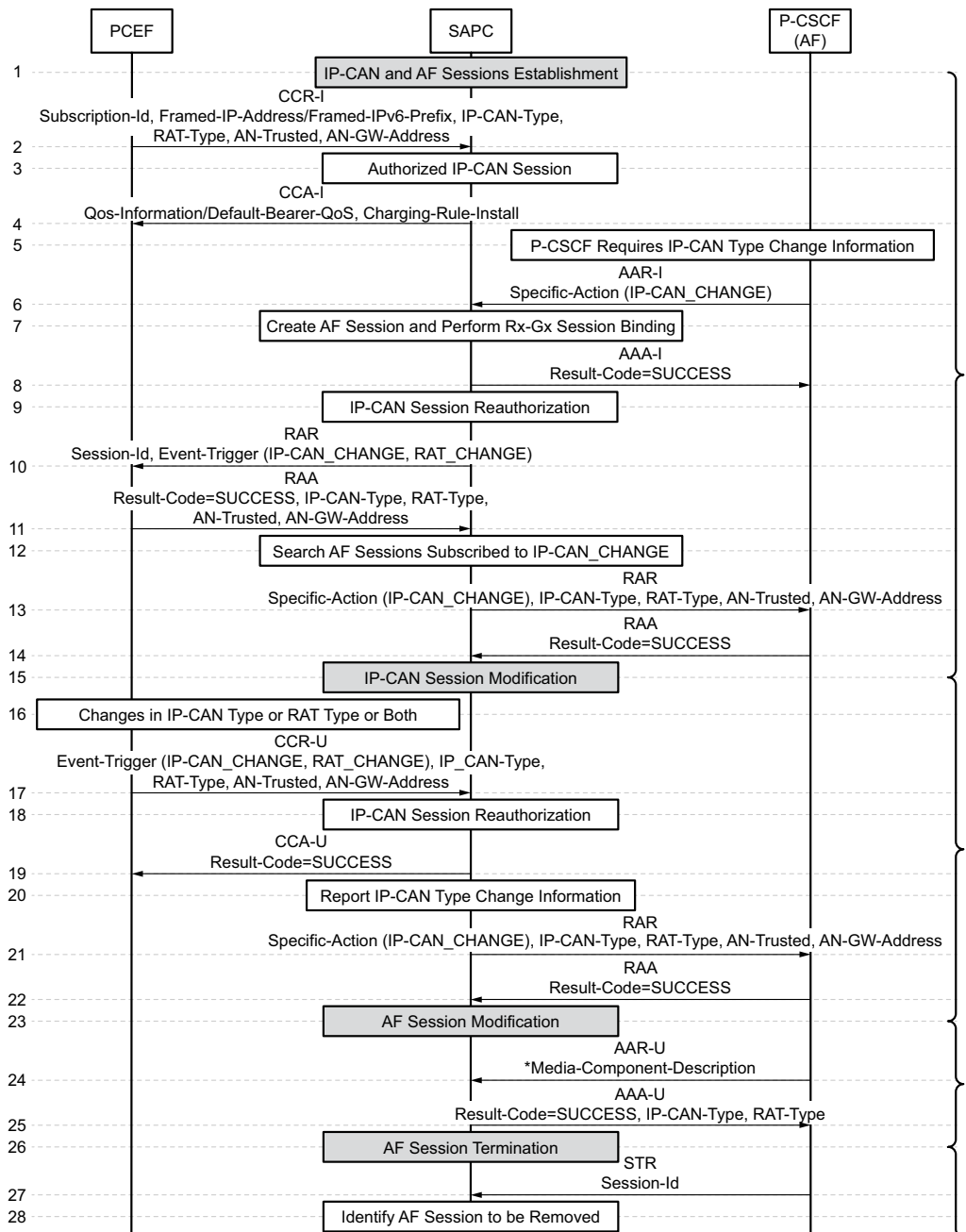


Figure 27 Subscription, Notification and Subscription Cancellation of the IP-CAN Type Change (I)

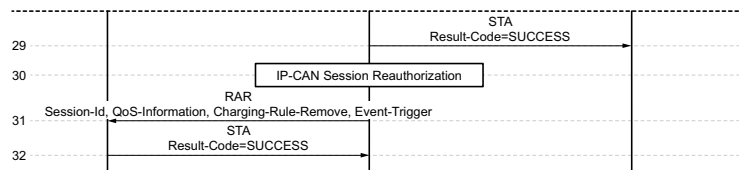


Figure 28 Subscription, Notification and Subscription Cancellation of the IP-CAN Type Change (II)

### IP-CAN and AF Sessions Establishment

- 2. The PCEF sends a CCR-I message to the SAPC. The information related to the IP-CAN type and RAT type is as follows:
  - The IP-CAN-Type AVP indicating the type "Non-3GPP-EPS".
  - The RAT-Type AVP indicating the type "WLAN".
  - The AN-Trusted AVP indicating the access network "UNTRUSTED". It means that the Non-3GPP-EPS access network is handled as untrusted.
  - The AN-GW-Address AVP with the ePDG address used as IPSec tunnel endpoint with the UE.
- 3. The SAPC authorizes the IP-CAN session.
- 4. The SAPC sends a CCA-I message to the PCEF for PCC rule installation.
- 5. The AF requires IP-CAN type change information.
- 6. The AF sends an AAR-I message to the SAPC, including the Specific-Action AVP with value IP-CAN\_CHANGE.

It indicates the AF subscribes to the change notification in UE's IP-CAN type and RAT type. The Specific-Action AVP is provided only at the AF session establishment and is applicable for the entire lifetime of the AF session.

For multiple AF sessions, all the AFs shall send the Specific-Action AVP with value IP-CAN\_CHANGE if they expect to receive the notifications of IP-CAN type changes in RARs.

- 7. The SAPC creates the AF session and binds the AF session with the existing IP-CAN session.
- 8. The SAPC accepts the AF's subscription to the notification of IP-CAN type change and answers with an AAA-I message.
- 9. The SAPC reauthorizes the IP-CAN session.

The SAPC performs event trigger selection. Because the AF already requests subscription of IP-CAN type notification, the SAPC automatically subscribes to the IP-CAN\_CHANGE and RAT\_CHANGE event triggers.



- 10. The SAPC sends an RAR to the PCEF with the `Event-Trigger` AVP including `IP-CAN_CHANGE` and `RAT_CHANGE` values.
- 11. The PCEF accepts the request with an RAA with the following AVPs:
  - The `Result-Code` AVP set to `SUCCESS`.
  - The `IP-CAN-Type` AVP indicating the type "Non-3GPP-EPS".
  - The `RAT-Type` AVP indicating the type "WLAN".
  - The `AN-Trusted` AVP indicating the access network "UNTRUSTED".
  - The `AN-GW-Address` AVP with the ePDG address used as IPSec tunnel endpoint with the UE.
- 12. The SAPC searches AF sessions that subscribed to IP-CAN change notification.
- 13. The SAPC sends an RAR message to notify the IP-CAN type change. The message includes the following main AVPs:
  - The `Specific-Action` AVP with value `IP-CAN_CHANGE`.
  - The `IP-CAN-Type` AVP indicating the type "Non-3GPP-EPS".
  - The `RAT-Type` AVP indicating the type "WLAN".
  - The `AN-Trusted` AVP indicating the access network "UNTRUSTED".

**Note:** The SAPC sends an RAR message including above AVPs when the information is changed or not previously sent to the AF.

  - The `AN-GW-Address` AVP with the ePDG address used as IPSec tunnel endpoint with the UE.
- 14. The AF answers back with an RAA including the `Result-Code` AVP set to `SUCCESS`.

### IP-CAN Session Modification

- 16. The PCEF detects changes in the IP-CAN type, RAT type, or both.
- 17. The PCEF sends a CCR-U message to the SAPC mainly with the following AVPs:
  - `Event-Trigger` AVP including the IP-CAN change, RAT change, or both events depending on the changes of the UE.
  - The `IP-CAN-Type` AVP indicating the type "3GPP-EPS".
  - The `RAT-Type` AVP indicating the type "EUTRAN".

- The AN-Trusted AVP is not included because it is not applicable. The PCEF provides AN-Trusted AVP only for Non-3GPP-EPS access network (not mandatory).
- The AN-GW-Address AVP containing the IPv4 and/or IPv6 address(es) of the access node gateway (if applicable).

**Note:** If the PCEF sends the IP-CAN-Type, RAT-Type, AN-Trusted and AN-GW-Address AVPs (if applicable) in CCR-U without the IP-CAN\_CHANGE or RAT\_CHANGE event trigger, the SAPC does not send an RAR to the AF with the AVPs.

- 18. The SAPC performs IP-CAN session reauthorization.
- 19. The SAPC answers back with a CCA-U.
- 20. The SAPC determines to report the IP-CAN type change information to the AFs which subscribed to the notification of IP-CAN type change.
- 21. The SAPC sends an RAR message to the AF to notify the IP-CAN type change. The message includes the following main AVPs:
  - The Specific-Action AVP with value IP-CAN\_CHANGE.
  - The IP-CAN-Type AVP indicating the type "3GPP-EPS".
  - The RAT-Type AVP indicating the type "EUTRAN".
  - The AN-GW-Address AVP containing the IPv4 and/or IPv6 address(es) of the access node gateway (if applicable).
- 22. The AF answers back with RAA including the Result-Code AVP set to SUCCESS.

### AF Session Modification

Steps 24-25 are applicable only when the AF sends the media information in an AAR-I message and the SAPC performs dynamic policy control at the AF session establishment.

- 24. The AF sends an AAR-U message to the SAPC to add a media component (when the Media-Component-Description AVP is included) or for gating.
- 25. The SAPC answers back with an AAA-U message including the following AVPs received from the PCEF:
  - The IP-CAN-Type AVP indicating the type "3GPP-EPS".
  - The RAT-Type AVP indicating the type "EUTRAN".

**Note:** The SAPC sends above AVPs in an AAA even if the IP-CAN type or RAT type is not changed.





### AF Session Termination

- 27. The AF sends an STR to indicate the termination of the AF session.
- 28. The SAPC identifies the session to be removed.
- 29. The SAPC accepts the termination of the AF session, and responds to the AF with an STA command including the Result-Code AVP set to SUCCESS.
- 30. The SAPC performs IP-CAN session reauthorization.

The SAPC detects no AF sessions bounded with the IP-CAN session and obtains the complete event trigger list without IP-CAN\_CHANGE or RAT\_CHANGE event trigger values (unless they are selected from event-triggers configuration).

- 31. The SAPC sends an RAR with the Session-Id AVP. In addition, the message may include the Event-Trigger AVP with value NO\_EVENT\_TRIGGERS if no event triggers are selected by the static configuration or the dynamic policy.
- 32. The PCEF answers back with an RAA including the Result-Code AVP set to SUCCESS.

## 4.3.6 Notification of Signalling Path Status

The following traffic cases show the signalling flow that takes place for notification of signalling path status. In general, the AF subscribes to notification of signalling path status in a dedicated Rx diameter session, which is different from the Rx diameter sessions for dynamic services activation or deactivation.

### 4.3.6.1 Notification of Release of AF Signalling Path

The precondition of the traffic case is that an AF signalling service is provisioned. That is, a static or preconfigured service, for example, AfSignalService is provisioned for the subscriber and added in the AF signalling path profile.

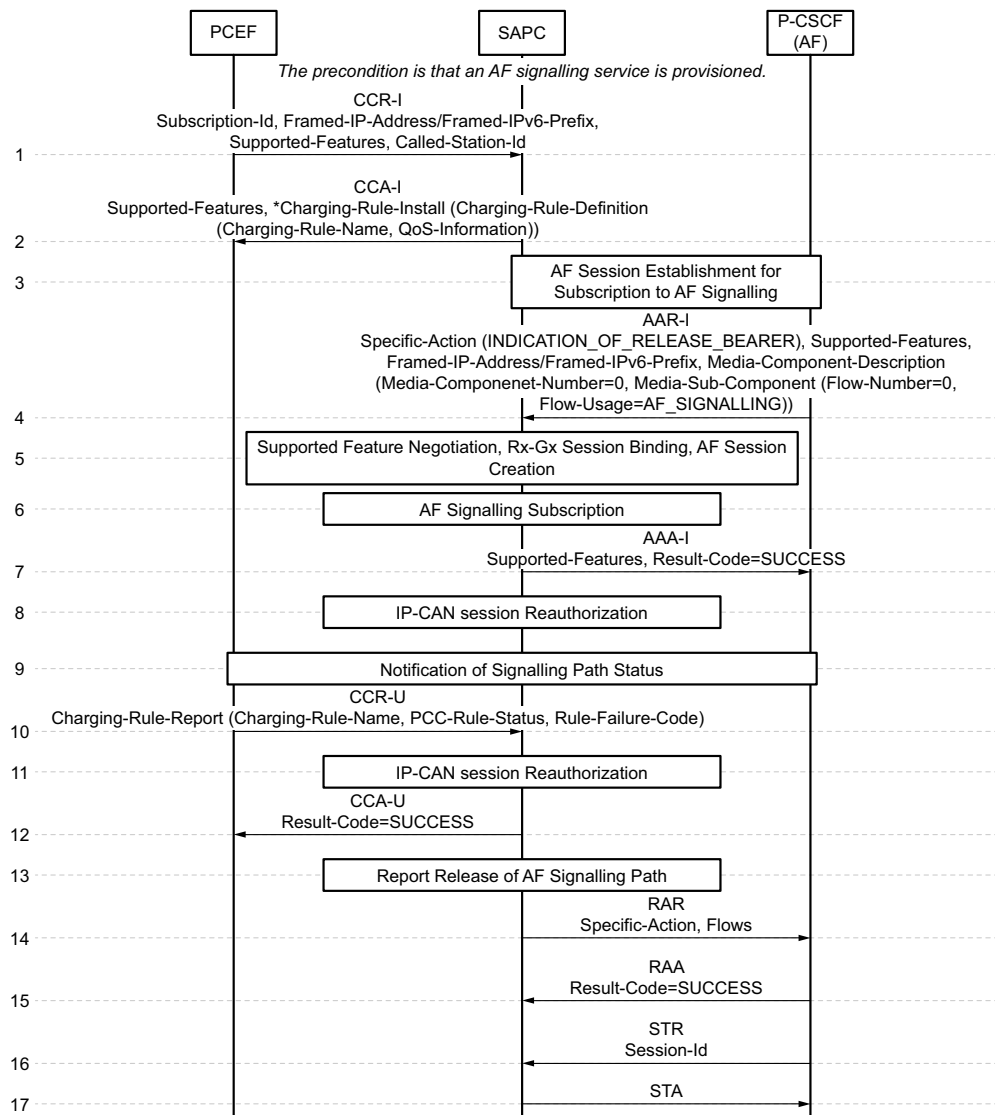


Figure 29 Notification of Release of AF Signalling Path

- 1. The SAPC receives a Gx CCR-Initial message from the PCEF indicating an IP-CAN session establishment.

The message includes the Called-Station-Id AVP with the APN value.

- 2. The SAPC sends a CCA-Initial message to the PCEF to install the PCC rule according to the service access control.

If the PCC rule set for the AF signalling service has a QCI different from the QCI of the default bearer, the installation of the PCC rule triggers the establishment of a dedicated bearer. Otherwise, the default bearer is used.

#### AF Session Establishment for Subscription to Notification of Signalling Path Status



- 4. The AF sends an AAR-I message to the SAPC to create an AF session for subscription to notification of signalling path status. The message includes the following AVPs:
  - Specific-Action AVP with the value INDICATION\_OF\_RELEASE\_OF\_BEARER
  - A Media-Component-Description AVP containing the following AVPs:
    - Media-Component-Number AVP set to 0
    - A single Media-Sub-Component AVP containing the following AVPs:
      - Flow-Number AVP set to 0
      - Flow-Usage AVP set to AF\_SIGNALLING
- 5. The SAPC negotiates the supported feature, binds the Rx-Gx session, and creates the AF session.
- 6. The SAPC accepts the AF's subscription to notification of signalling path status.

The SAPC searches the AF signalling path profile to identify the AF signalling service defined for the APN of the bound Gx session. If no service based on an APN is found, the SAPC uses the default service. The SAPC sets the status of the AF signalling service to "subscribed to the AF signalling path".

- 7. The SAPC sends an AAA-I message with Result-Code set to SUCCESS (2001) to the AF.
- 8. The SAPC performs the IP-CAN session reauthorization and decides to provision a new PCC rule or QoS based on the policy evaluation result if applicable. In this traffic case, the SAPC does not send an RAR to the PCEF, because the PCC rule for the AF signalling service is sent in Gx CCA-I and the QoS is not changed at reception of Rx AAR-I.

If the AF signalling service is not authorized, the SAPC requests the PCEF to remove the corresponding PCC rule. Then the SAPC sends an RAR message to the AF with the same information listed in step 14. The subsequent steps are the same to steps 15-17.

#### Notification of Release of AF Signalling Path

- 10. The PCEF reports a resource allocation failure for the AF signalling PCC rule by sending a CCR-U message with the Charging-Rule-Report AVP including:
  - Charging-Rule-Name AVP indicating the PCC rule for the AfSignalService
  - PCC-Rule-Status AVP set to INACTIVE
  - Rule-Failure-Code AVP set to RESOURCE\_ALLOCATION\_FAILURE

- 11. The SAPC performs IP-CAN session reauthorization, updating the session information and removing the affected PCC rule.
- 12. The SAPC accepts the notification and answers back with CCA-U including the new or modified policy and charging control information as result of the IP-CAN session reauthorization.
- 13. The SAPC decides to notify the release of AF signalling path to the AF.
- 14. The SAPC notifies the release of AF signalling path to the AF by sending an RAR message with:
  - Specific-Action AVP set to INDICATION\_OF\_RELEASE\_OF\_BEARER
  - Flows AVP with:
    - Media-Component-Number AVP set to 0
    - Flow-Number AVP set to 0
- 15. The AF answers back with an RAA including the Result-Code AVP with value SUCCESS.
- 16. The AF sends an STR command to request the termination of the AF session.
- 17. The SAPC sends an STA command to the AF.

#### 4.3.6.2

#### Notification Due to IP-CAN Session Termination

In case the AF signalling path is running on the default bearer and no AF signalling path profile is provisioned, the SAPC accepts the AF's subscription but can only notify the AF at the IP-CAN session termination.

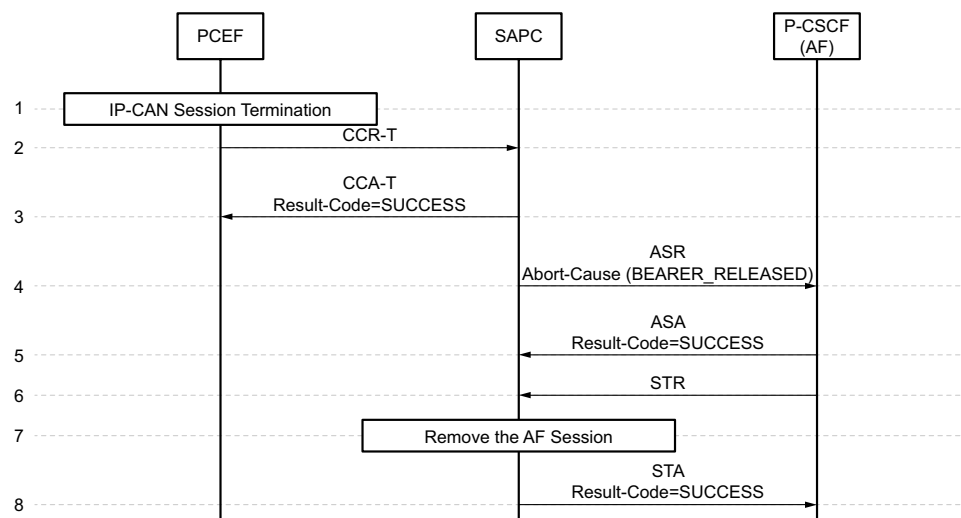


Figure 30 Notification Due to IP-CAN Session Termination



- 1. The PCEF removes the IP-CAN session.
- 2. The PCEF sends a CCR-Terminate message to the SAPC.
- 3. The SAPC answers back with a CCA-Terminate message.
- 4. The SAPC sends an ASR message to the AF, including the Abort -Cause AVP set to BEARER\_RELEASED.
- 5. The AF answers back with an ASA message.
- 6. The AF sends an STR message to terminate the AF session.
- 7. The SAPC removes the AF session.
- 8. The SAPC answers with an STA including the Result-Code AVP set to SUCCESS.

#### 4.3.6.3

#### Cancellation of Subscription to Signalling Path Notification

When the AF wants to cancel the subscription to notification of signalling path status, the AF shall send an STR to the SAPC to terminate the AF session. The SAPC takes the following actions:

- Identifies the AF session affected.
- Removes the AF session and answers with an STA command with the Result-Code AVP set to SUCCESS.

Because the status of the AF signalling service is stored in the AF session, the subscription status is removed if it had been set to "subscribed to the AF signalling path".

- Performs the IP-CAN session reauthorization and decides whether or not to send an RAR to the PCEF based on the policy evaluation result.

If the STR message is lost and the AF sends a new AAR-I with subscription to AF signalling path, the SAPC accepts the new subscription and removes the previous subscription.

## 4.4

## IMS Related Procedures

### 4.4.1

### SIP Forking

The following figure shows the signalling flow that takes place when the IMS network performs SIP forking and the AF (P-CSCF) receives provisional responses from more than one possible contact destination. In this particular traffic case, the UE initiates a voice-over-LTE call setup towards a remote UE that has two contact addresses registered in the IMS network. Each terminating end point initiates an

early dialog and request authorization and resource reservation to the SAPC. Finally the remote party answers the call.

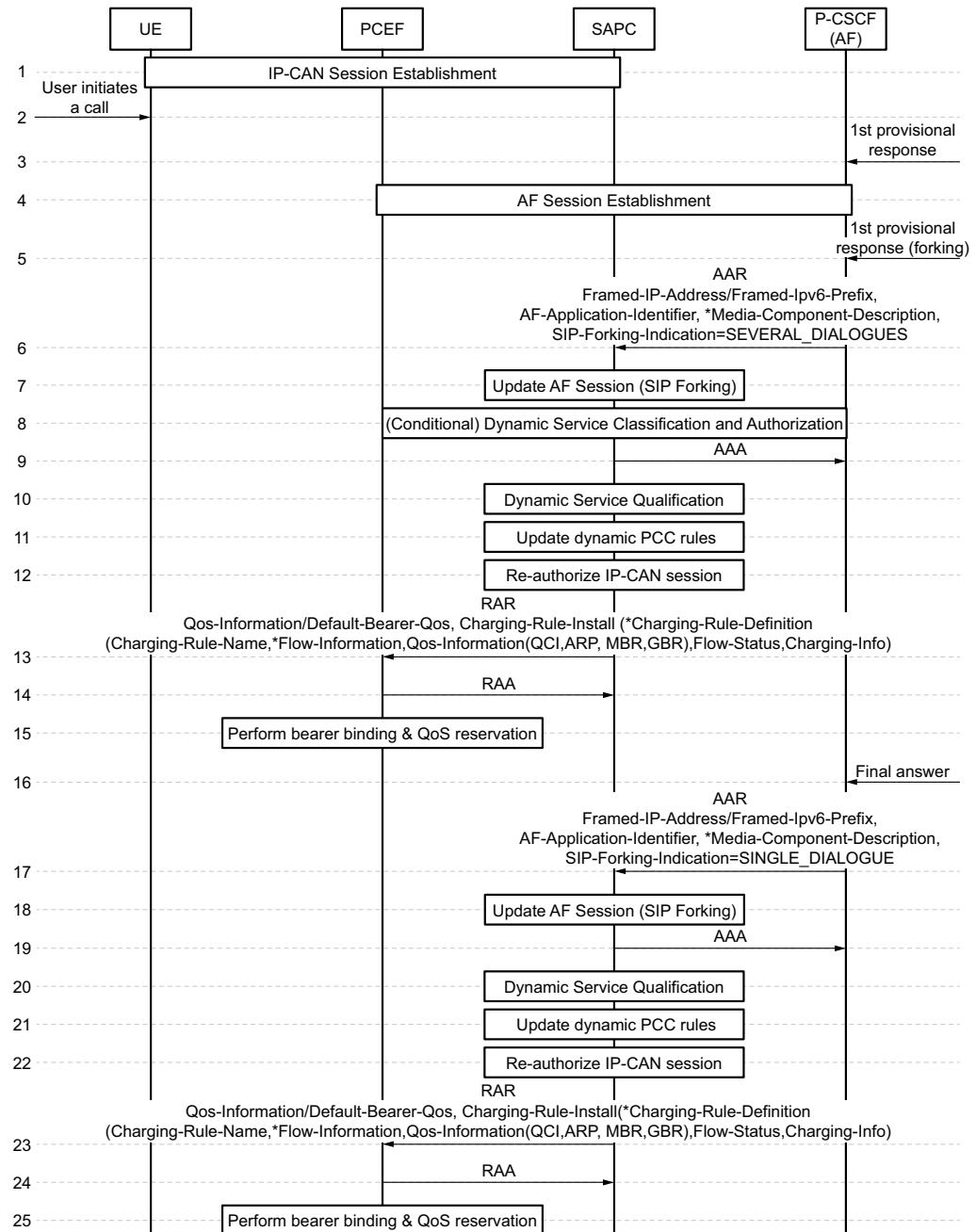


Figure 31 SIP Forking

- 1. The UE has established an IP-CAN session.
- 2. The UE initiates a voice-over-LTE call setup towards a remote UE that has two contact addresses registered in the IMS network.



- 3. The AF (P-CSCF) receives the provisional response from one of the possible contact destinations.
- 4. The AF performs the session establishment procedure to request authorization and resource reservation to the SAPC, as detailed in Section 4.1.1 on page 34. For this traffic case, as an example, the AAR command includes one media component of type AUDIO, with a bandwidth requirement of 29 kbps. The SAPC generates two dynamic PCC rules: one for the RTP media sub-component, and another PCC rule for the RTCP media sub-component.
- 5. The AF (P-CSCF) receives the provisional response from another possible contact destination because of forking.
- 6. The SAPC receives an AAR message from the AF to modify an existing AF session including the session identifier and the SIP-Forking-Indication AVP set to the value SEVERAL\_DIALOGUES. The AF provides the service information for this provisional response within the Media-Component-Description AVP(s). For this traffic case, as an example, the AAR command includes one media component of type AUDIO, with a bandwidth requirement of 41 kbps.
  - If the second provisional response contains additional media (for example, VIDEO), the AAR command contains a Media-Component-Description AVP with a new ordinal number in the Media-Component-Number AVP.
- 7. The SAPC updates the AF session state taking into account that this is a provisional response because of forking. This means that the SAPC does not overwrite the existing session information with the information received from the AF, but the SAPC needs to merge the information received from both forking legs.
- 8. If the SAPC identifies that the updated AF session contains new media components, the SAPC performs the dynamic service classification and authorization of the new media.
- 9. The SAPC responds to the AF with an AA-Answer command indicating the operation result. If the request is successfully, the Result-Code AVP is set to the value SUCCESS. If the request is unsuccessful, an error code is indicated.
- 10. The SAPC determines the QoS and Charging information so that the SAPC authorizes the maximum bandwidth required by any of the dialogues, but not the sum of the bandwidths required by all dialogues.
  - If the second provisional response contains additional media (for example, VIDEO), the SAPC also determines the QoS and Charging information associated with any additional dynamic service.
- 11. The SAPC updates the installed dynamic PCC rules for the first provisional response, and adds the additional service data flow filters corresponding to the second provisional response, so that the QoS authorized for a media component is equal to the highest QoS requested for that media component

by any of the forked responses. For this traffic case, as an example, the MBR/GBR is set to 41 kbps.

- If the second provisional response contains additional media (for example, VIDEO), the SAPC generates new dynamic PCC rules.
- 12-15. The SAPC performs the reauthorization of the IP-CAN session and provisions the policy control and charging information to the PCEF.
- 16. When the terminating party answers the call, the AF (P-CSCF) receives the final SIP response.
- 17. The SAPC receives an AAR message from the AF to modify an existing AF session with no SIP-Forking-Indication AVP or with the SIP-Forking-Indication AVP set to the value SINGLE\_DIALOGUE. The AF provides the full service information for the SIP session within the Media-Component-Description AVP(s), including the applicable Flow-Description AVP(s) and Flow-Status AVP(s).
- 18. The SAPC updates the AF session state to match the requirements of the service information within this final AAR message only.
- 19. The SAPC responds to the AF with an AA-Answer command indicating the operation result.
- 20-22. The SAPC determines the QoS and Charging information according to the service information provided in the final AAR message, updates the installed dynamic PCC rules and performs the reauthorization of the IP-CAN session.
- 23-25. The SAPC provisions the policy control and charging information to the PCEF.

#### 4.4.2 Single Radio Voice Call Continuity

The following figure shows the signalling flow that takes place when dynamic PCC rules cannot be installed/activated or enforced at the PCEF, and the main actions taken by the SAPC to perform dynamic policy control.



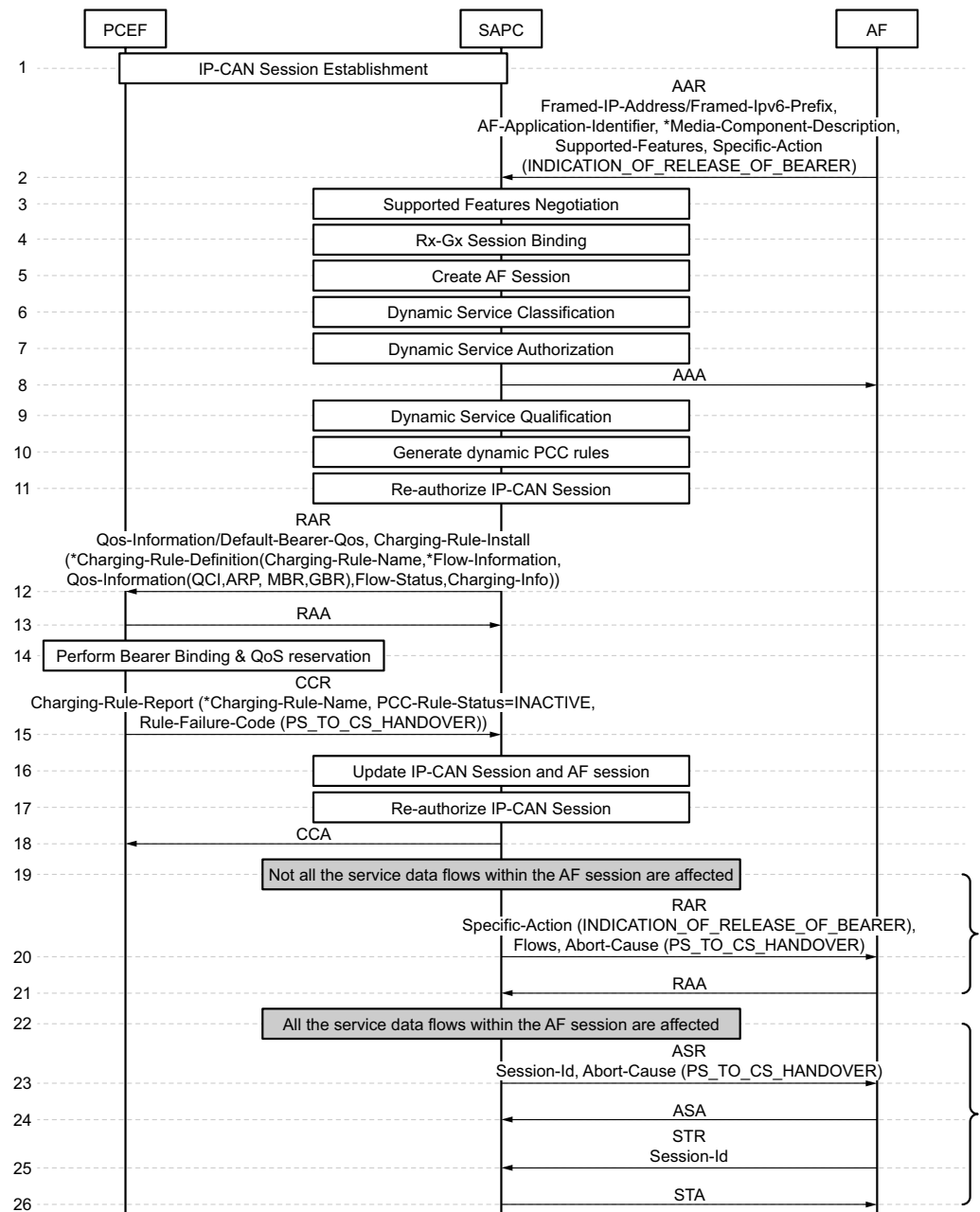


Figure 32 Single Radio Voice Call Continuity

This traffic case is similar to the one explained in section Service Data Flow Deactivation. The main differences are highlighted below.

- 2. In addition to the service information, the SAPC receives the list of bearer events that the AF requests to be notified in the Specific Action AVP, which includes the value INDICATION\_OF\_RELEASE\_OF\_BEARER.

- 15. The PCEF sends a CCR-Update that includes a Charging-Rule-Report AVP with the PCC-Rule-Status AVP set to the value INACTIVE, the list of failed PCC rules, and the Rule-Failure-Code AVP set to the value PS\_TO\_CS\_HANDOVER. This indicates to the SAPC that the PCC rule(s) could not be maintained because of PS to CS handover.
- 20. If not all the service data flows within the AF session are affected and the AF has requested to be notified, SAPC sends an RAR message to the AF with the Abort-Cause AVP set to the value PS\_TO\_CS\_HANDOVER, the list of deactivated IP Flows encoded in the Flows AVP and the Specific-Action AVP set to INDICATION\_OF\_RELEASE\_OF\_BEARER.
- 23. If all the service data flows within the AF session are deactivated, the SAPC informs the AF by sending an ASR command, including the Abort-Cause AVP set to the value PS\_TO\_CS\_HANDOVER. The SAPC sends the command in this case regardless of whether the AF has previously subscribed to any notification event.

#### 4.4.3 Provisioning of AF Signalling Flow Information

The following figure shows the signalling flow that takes place when the IMS network triggers Provisioning of AF Signalling Flow Information PCC procedure over Rx reference point.

When the P-CSCF has successfully concluded the initial registration of an attached UE, i.e., when the P-CSCF has sent to the UE a SIP 200 (OK) response to the SIP REGISTER request, the P-CSCF may provision information about the SIP signalling flows between the UE and itself using following procedure.

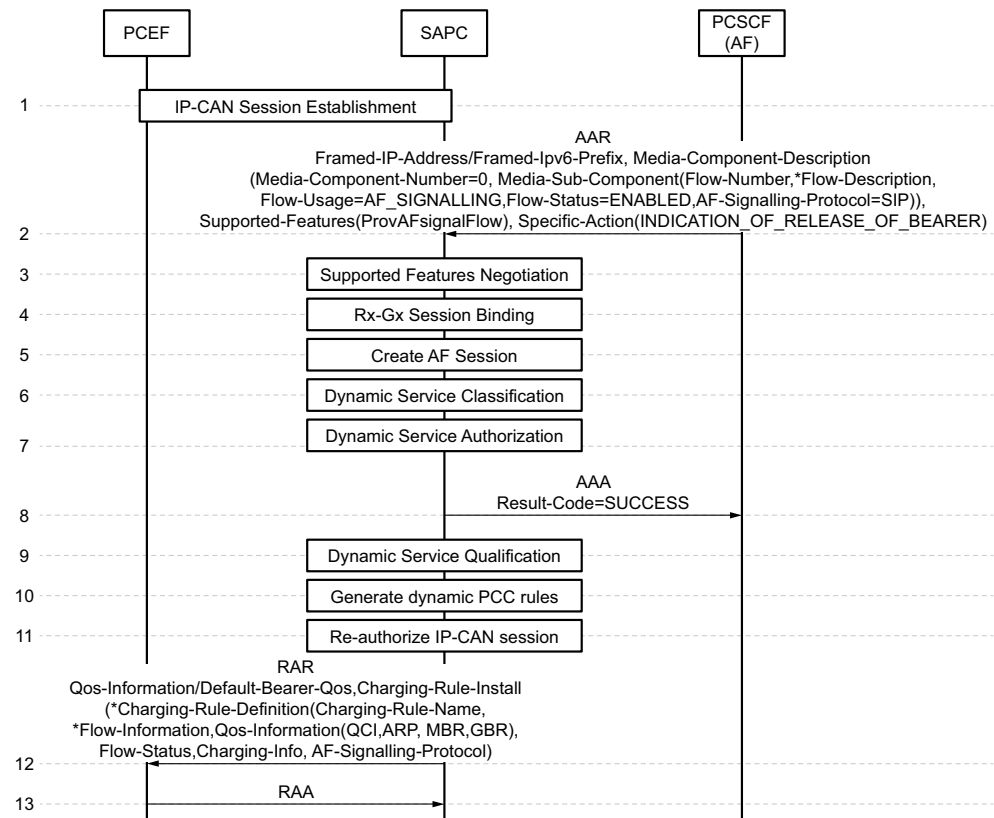


Figure 33 Provisioning of AF Signalling Flow Information in an AF Signalling Session Establishment

Steps are similar to the ones explained in section AF Session Establishment. Next, the main differences are highlighted.

- 1. The UE has established an IP-CAN session. The SAPC sends a CCA-Initial command to the PCEF with the Supported-Features AVP with the ProvAFsignalFlow bit set if the SAPC receives a Gx CCR-Initial command from the PCEF including the Supported-Features AVP with the ProvAFsignalFlow bit set and the dynamic policy control function is enabled.
- 2. The AF (P-CSCF) provisions the AF signalling flow information between the UE and the AF sending an AAR to the SAPC with following specific AVPs:
  - Supported-Features AVP with the ProvAFsignalFlow bit set
  - A Media-Component-Description AVP containing the following AVPs:
    - Media-Component-Number AVP set to 0
    - One or more Media-Sub-Component AVP(s) representing the AF signalling IP flows. Each Media-Sub-Component AVP contains:
      - Flow-Number AVP set to a value different than 0

- Flow-Usage AVP set to AF\_SIGNALLING
  - Flow-Status AVP set to ENABLED
  - AF-Signalling-Protocol AVP set to the value corresponding to the signalling protocol used between the UE and the AF (optional)
  - Specific-Action AVP with the value INDICATION\_OF\_RELEASE\_OF\_BEARER could be included in the AAR-I.
- 3. The SAPC determines the set of supported features that it has in common with the AF. If the SAPC receives a AAR-Initial command from the PCEF including the Supported-Features AVP with the ProvAFsignalFlow bit set, the SAPC sends a AAA command to the AF with the Supported-Features AVP with the ProvAFsignalFlow bit set when Result-Code AVP value is 2001 (SUCCESS).
- 4-5. The SAPC creates the AF session and binds the AF session with an existing IP-CAN session.
- Note:** If the P-CSCF already has an open Rx Diameter session with the PCRF related to the signalling with the UE, e.g. one that has been opened according to Subscription to Signalling Path Status procedure and/or Subscription to IP-CAN type Change procedure, the P-CSCF reuses the already open session to provision the SIP Signalling IP Flow information. Otherwise it opens a new Rx Diameter session related to the AF signalling. This is a different Rx diameter session that the one used to provision media information (e.g. for a VoLTE call).
- 12. The SAPC sends an RAR message to the PCEF. The SAPC provides the Charging-Rule-Install AVP including the Charging-Rule-Definition AVP(s). The Charging-Rule-Definition AVP includes in the Flow-Information AVP the signalling flows between UE and the AF and the AF-Signalling-Protocol AVP set to the value corresponding to the signalling protocol used between the UE and the AF. If AF-Signalling-Protocol is not provided over Rx reference point, the value NO\_INFORMATION is assumed and set. If ProvAFsignallingFlow supported feature is not supported by the PCEF, AF-Signalling-Protocol is not provided.
- 13. The PCEF accepts the installation of PCC rules.



**Note:** The AF may subscribe to notifications by including in the AAR-I the Specific-Action AVP set to INDICATION\_OF\_RELEASE\_OF\_BEARER, together with the provision information about the AF signalling flows. Then, if the PCC rules cannot be installed or are deactivated at the PCEF at any time, the PCEF sends a Charging-Rule-Report AVP specifying the affected PCC rules with the PCC-Rule-Status set to inactive and including the Rule-Failure-Code AVP assigned to the value RESOURCE\_ALLOCATION\_FAILURE. Upon reception of the deactivation of the PCC rules for AF signalling, the SAPC notifies the AF by sending an Rx RAR message including the Specific-Action AVP set to the value "INDICATION\_OF\_RELEASE\_OF\_BEARER" and the deactivated IP Flow encoded in the Flows AVP. When the AF receives the RAR command, the AF may then decide to terminate the Rx Diameter session associated to the AF Signalling transmission path.

## 4.5 Dynamic Policy Control Triggered by Application Service Detection

This chapter shows the most common traffic cases that may happen in network scenarios where the AF does not provide specific information about the IP flows required to deliver the service (the media component information is not present), but merely provides an application identifier that triggers the activation of a dynamic service in the SAPC.

A typical example is when a DPI node (acting as AF) detects the start of an application service and reports this event to the SAPC over the Rx interface. Then the SAPC does not generate dynamic PCC rules, but reevaluates the applicable policies for the IP-CAN session based on the received information about the service detection. As a result, the SAPC may, for example, upgrade the QoS of the default bearer to accommodate the application service, terminate the IP-CAN session (for example in the case of tethering) or reduce the assigned QoS for that service (for example, P2P service throttling).

### 4.5.1 Dynamic QoS Control based on Detected Service

This traffic case shows how the SAPC upgrades the QoS of the default bearer when a DPI node detects the start of a streaming service. In addition, the SAPC can also request the PCEF to initiate the establishment of a dedicated bearer for the delivery of the service.

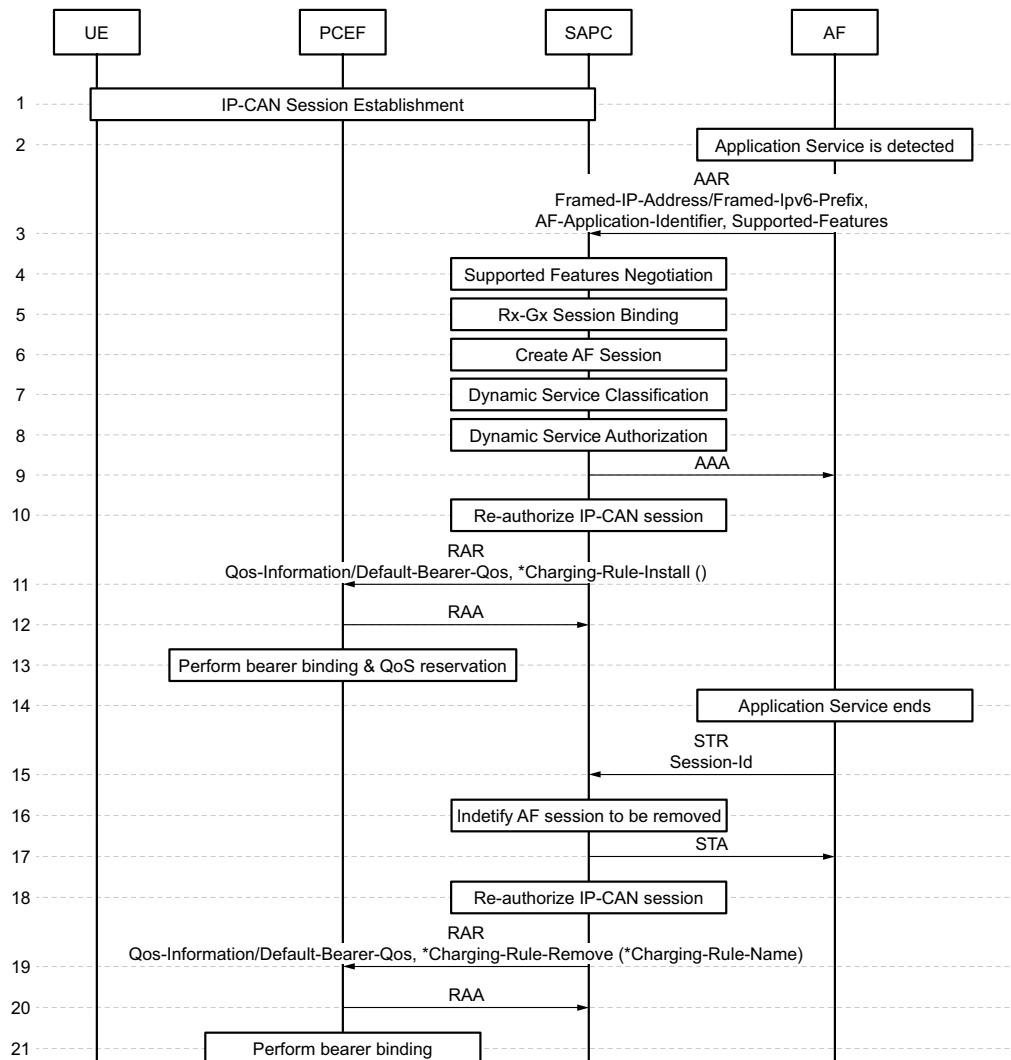


Figure 34 Dynamic QoS based on Detected Service

- 1. The UE has established an IP-CAN session.
- 2. The AF (DPI) detects the start of an application service through packet inspection.
- 3. The AF (DPI) reports the activation of an application service to the SAPC using the Rx interface. The SAPC receives an AAR message from the AF to establish a new AF session. The main information that the AF provides is:
  - The IPv4 or IPv6 address that identifies the UE terminal.
  - The AF-Application-Identifier AVP that identifies the application service that has been detected.



- The set of supported features required for the AF session, in the Supported-Features AVP.
- Steps 4–9 are similar to the ones explained in section AF Session Establishment.
- 10. The SAPC performs reauthorization of the IP-CAN session based on the information received about the detected service, the subscription information, and the applicable policies. For this use case, the SAPC upgrades the QoS for the default bearer. In addition, the SAPC may also authorize other static or pre-configured services for the IP-CAN session. This permits for example to select pre-configured PCC rules defined in the SAPC that are installed when a notification of service activation is received from the AF. These pre-configured PCC rules can have a QCI different than the QCI of the default bearer, and the installation of these PCC rules triggers the establishment of a dedicated bearer.
- 11. The SAPC sends to the PCEF the quality of service for the default bearer and optionally additional PCC rules and QoS information that result from the policy evaluation.
- 12. The PCEF accepts the modification of the default bearer and the installation/removal of PCC rules.
- 13. The PCEF performs the bearer binding and modifies the default bearer. In addition, the PCEF initiates a dedicated bearer if there is not an existing one that fulfills the quality of service requirements of the provisioned PCC rules.
- 14. The AF (DPI) detects the stop of the application service through packet inspection.
- 15. The AF (DPI) notifies the stop of the application service to the SAPC sending an STR message that includes the session identifier,
- 18. The SAPC performs reauthorization of the IP-CAN session based on condition that the application service has stopped. For this use case, the SAPC reevaluates the QoS to apply to the default bearer and downgrades the QoS back to the original state. In addition, the SAPC may also remove other static or pre-configured services from the IP-CAN session. This permits the SAPC to trigger the release of the dedicated bearer that was set up when the application service was detected.
- 19. The SAPC sends to the PCEF the quality of service for the default bearer and removes the PCC rules.
- 21. The PCEF performs the bearer binding and modifies the default bearer. If applicable, the PCEF also removes the PCC rules and releases the dedicated bearer.

## 4.5.2

### Deactivation of IP-CAN Session on Detection of Tethering Traffic

This traffic case shows an example of IP-CAN session termination initiated by the SAPC upon detection of tethering traffic.

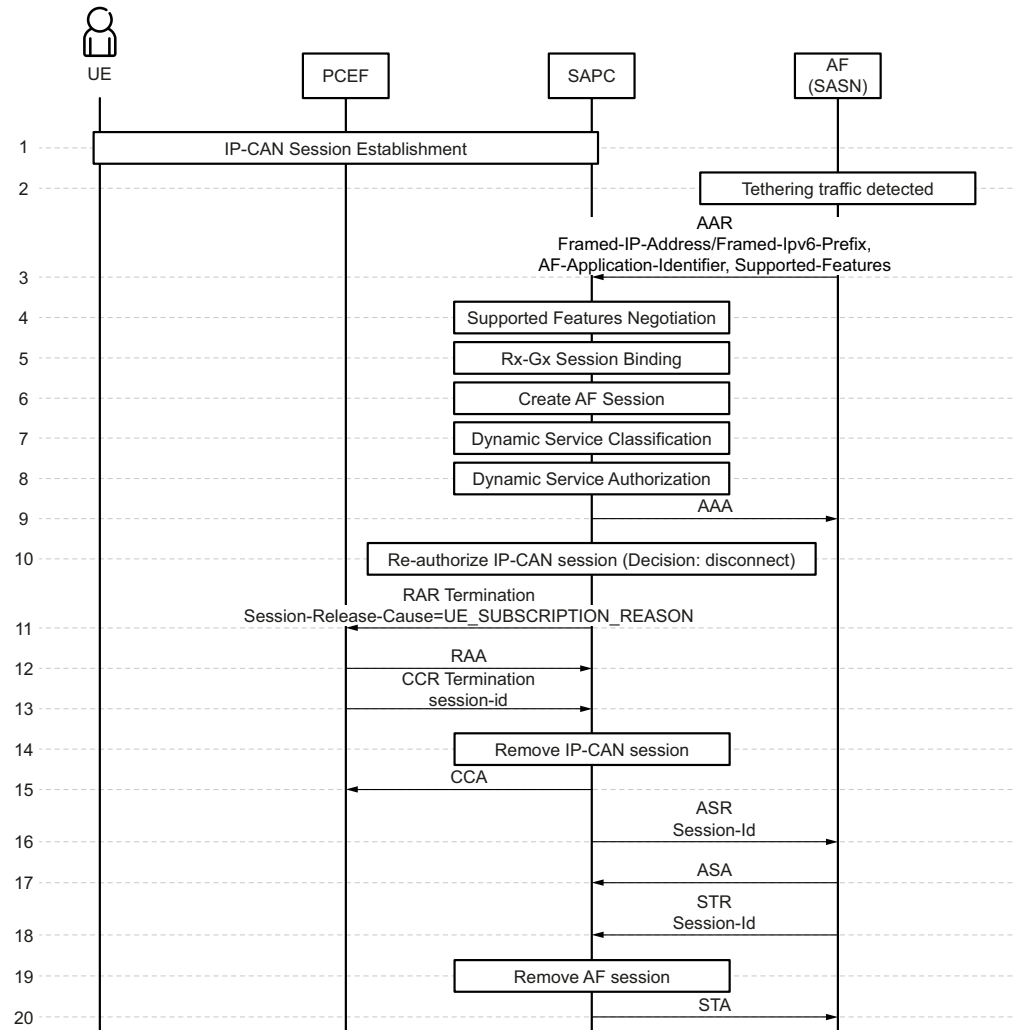


Figure 35 Deactivation of IP-CAN Session on Detection of Tethering Traffic

- 1. The UE has established an IP-CAN session.
- 2. The AF (DPI) detects the start of tethering traffic through packet inspection.
- 3. The AF (DPI) reports the detection of tethering traffic to the SAPC using the Rx interface. The SAPC receives an AAR message from the AF to establish a new AF session. The main information that the AF provides is:
  - The IPv4 or IPv6 address that identifies the UE terminal.
  - The AF-Application-Identifier AVP that identifies the application service that has been detected (tethering).





- The set of supported features required for the AF session, in the Supported-Features AVP.
- Steps 4–9 are similar to the ones explained in section AF Session Establishment.
- 10. The SAPC performs reauthorization of the IP-CAN session based on the information received about the detected service. For this use case, the SAPC decides to reject the IP-CAN session.
- 11. The SAPC sends an RAR message to the PCEF with Session-Release-Cause AVP set to the value UE\_SUBSCRIPTION\_REASON, to request the termination of the IP-CAN session.
- 12-13. The PCEF answers with an RAA command and sends a CCR Termination message to the SAPC.
- 16. The SAPC informs the AF about the IP-CAN session termination by sending an command on each active Rx Diameter session.

## 4.6 Handling of Race Conditions Related to Multiple AF Requests

The following signalling flow shows how the SAPC handles diameter race condition errors related to multiple AF requests for the same in an IP-CAN session.

In this particular traffic case, the UE (a first responder such as Police, Fire Fighter or Medical Emergency) access the Public Safety LTE network, and is granted a dedicated communication control channel to the Public Safety Agency (PSA). When an incident occurs, the PSA (AF) elevates the priority of the control channel to the UE, and also establishes additional dedicated bearers for data transmission. Moreover, the PSA (AF) requires the SAPC to notify the successful outcome of the resource allocation procedure related to the public safety services.

This results in the AF performing multiple Rx session creation and modification requests in short succession for the same subscriber and IP-CAN session that may overlap in time with CCR-U messages from the PCEF.

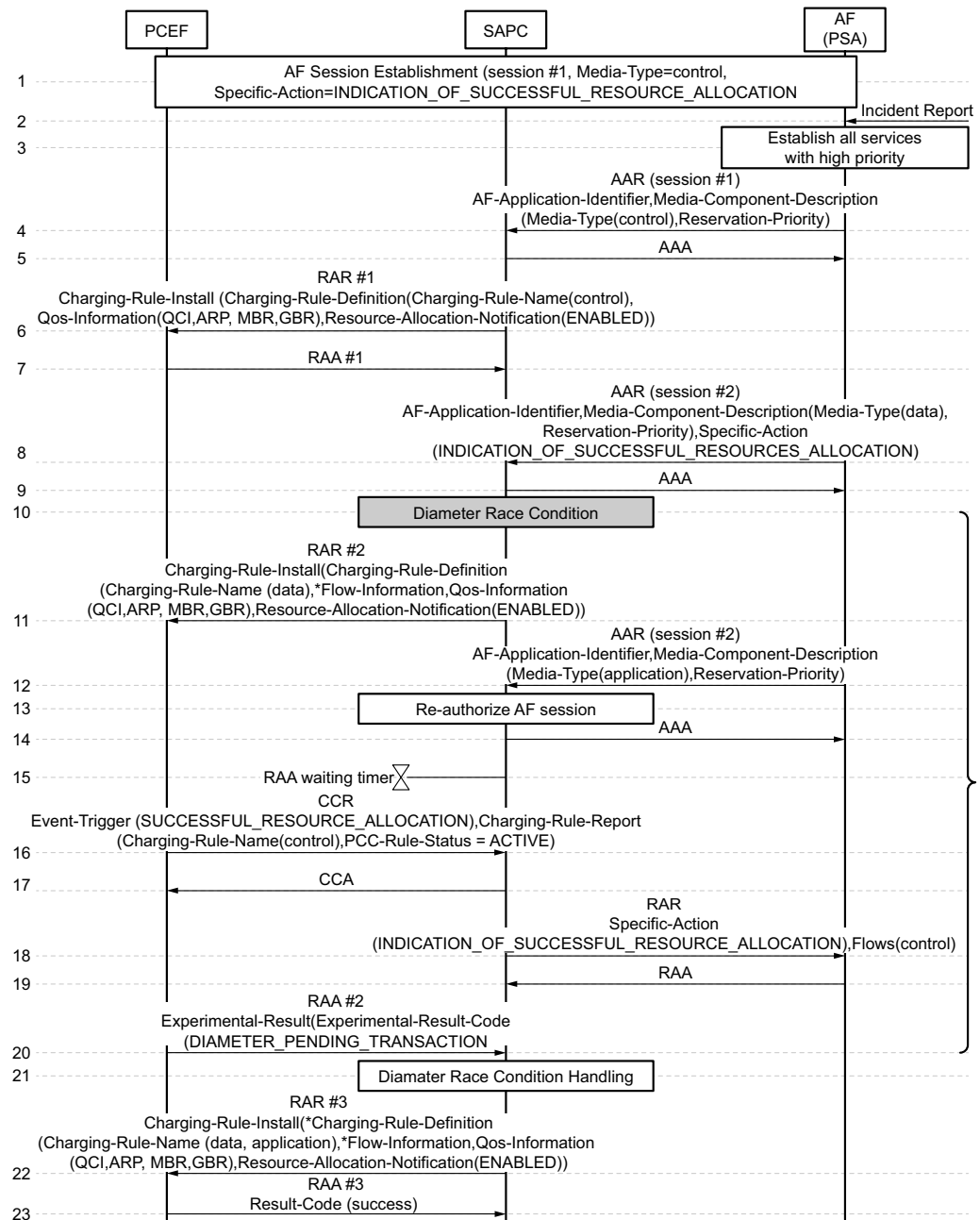


Figure 36 Handling of Race Conditions Related to Multiple AF Requests

- 1. The AF performs the session establishment procedure, as detailed in Section 4.1.1 on page 34. In this traffic case, the AAR command includes one media component of type CONTROL, and the AF subscribes to notifications of successful resources allocation.
- 2-3. The AF requires the establishment of high priority services for the subscriber, for example due to reception of an incident report from the Public Safety Application (PSA).



- 4. The AF sends an AAR message to the SAPC to modify the priority level of the CONTROL media path.
- 5. The SAPC updates the AF session and responds with an AAA command to the AF.
- 6. The SAPC sends an RAR message to the PCEF to update the installed dynamic PCC rules for the CONTROL service with higher priority level. The RAR message includes the Resource-Allocation-Notification AVP set to ENABLED to indicate the PCEF that a confirmation about resource allocation is required.
- 7. The PCEF accepts the installation of the PCC rules.
- 8. The SAPC receives an AAR message from the AF to establish a new AF session including a media component of type DATA, and the request to provide a notification when the resources associated to the corresponding service information have been allocated.
- 9. The SAPC binds the new AF session to the same IP-CAN session that is associated to the AF session established in step 1. The SAPC performs a re-authorization of the AF session and responds with an AAA command to the AF.

#### **Diameter Race Condition**

- 11. The SAPC sends an RAR message to the PCEF to install the dynamic PCC rules for the DATA service with high priority level, including the indication to the PCEF that a confirmation about resource allocation is required. This message overlaps in time with a PCEF-initiated IP-CAN session modification in step 16, creating a race condition situation.
- 12. The SAPC receives an AAR message from the AF to add a media component of type APPLICATION to the AF session established in step 8.
- 13-14. The SAPC updates the AF session and responds with an AAA command to the AF.
- 15. The SAPC detects that there is a previous Gx RAR pending to be acknowledged for the same IP-CAN session, and starts a timer to wait for the RAA message. No Gx RAR message is sent to the PCEF at this point in time.
- 16. The SAPC receives the CCR-U message with the notification from the PCEF that the resources associated to the CONTROL service information have been successfully allocated. This message overlaps in time with a SAPC-initiated IP-CAN session modification in step 11, creating a race condition situation.
- 17. The SAPC accepts the notification and does not perform a policy re-evaluation if the CCR command only includes the Event-Trigger AVP set to SUCCESSFUL\_RESOURCE\_ALLOCATION.

**Note:** In general, the SAPC performs a reauthorization of the IP-CAN session based on the information received in the CCR-U message, and sends the updated policy control information in the CCA. However, if the AF has requested the SAPC to report the access network information for this IP-CAN session (for example in step 12), the SAPC skips policy evaluation for static, preconfigured, and dynamic services in the IP-CAN session re-authorization.

- 18-19. The SAPC notifies the AF that the resources associated to the CONTROL service information have been successfully allocated.
- 20. As a result of the race condition situation, the PCEF rejects the RAR message from the SAPC in step 11 and sends an RAA with an `Experimental-Result` AVP including the `Experimental-Result-Code` AVP set to `DIAMETER_PENDING_TRANSACTION`.
- 21. The SAPC stops the timer set in step 15. If the configured maximum number of reattempts is not reached, the SAPC performs a reauthorization of the IP-CAN session and determines the policy control information pending to be sent to the PCEF (for details see [Access and Charging Control \(Gx\)](#)).
- 22. The SAPC sends a re-attempting RAR message to the PCEF with the latest policy information. In this case, the SAPC includes the PCC rules to be installed for the DATA service and also for the APPLICATION service.
- 23. The PCEF accepts the installation of the PCC rules and returns an RAA message including the `Result-Code` AVP with value `SUCCESS`.

## 4.7 Delay PCC Rules Installation for AF Sessions with Preliminary Service Information

The following signalling flows show how the SAPC handles dynamic PCC rules generated for preliminary and final AF sessions when delaying the installation of PCC rules for preliminary AF sessions.

### 4.7.1 Delay installation of PCC rules for a Preliminary AF Session

This traffic case shows an example of delaying the installation of PCC rules for preliminary AF sessions, i.e. AF sessions with preliminary service information that needs to be further negotiated between the two ends, and installing them when the AF session becomes final, i.e. AF sessions for which the service has been fully negotiated between the two ends and the service information provided is the result of that negotiation.

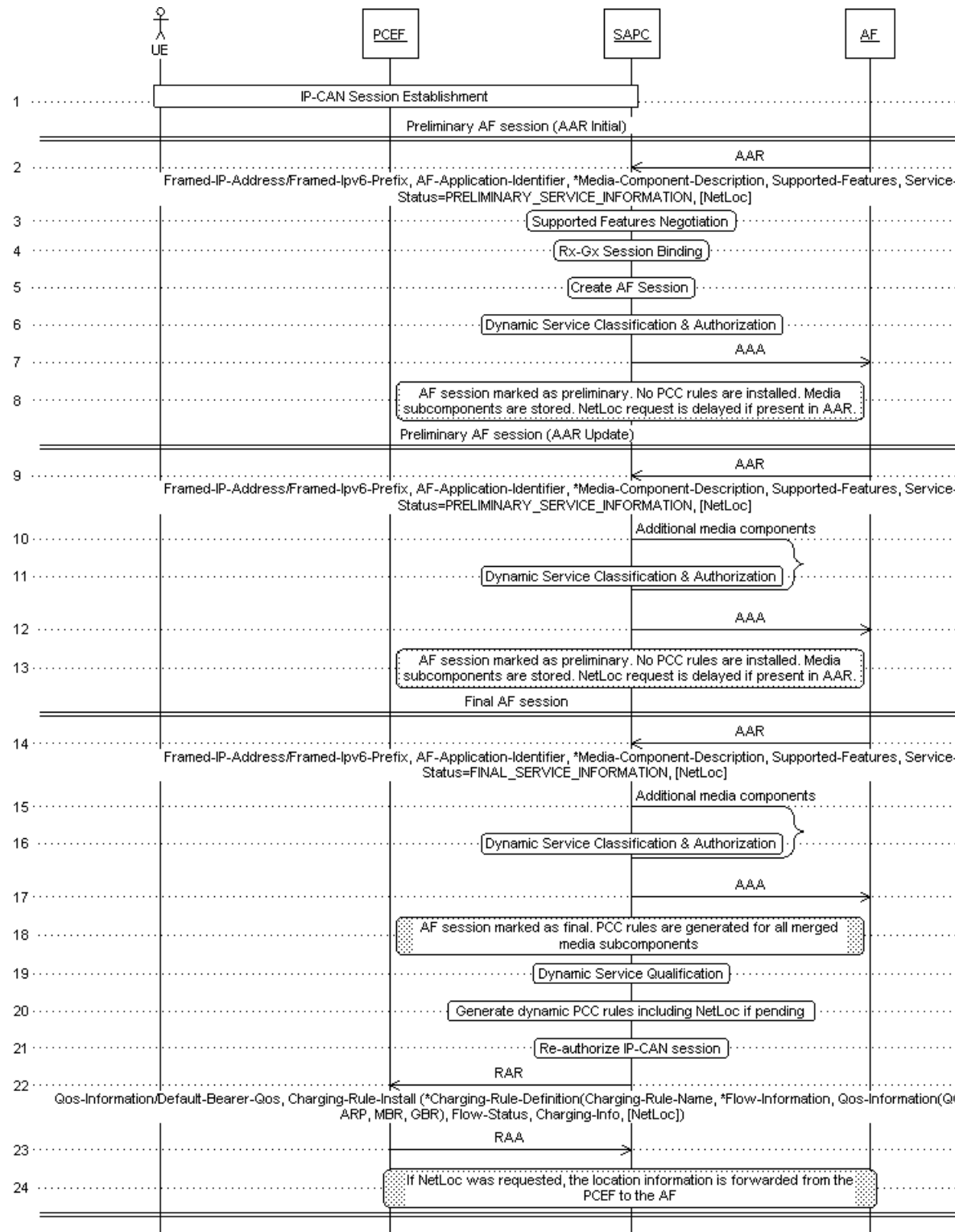


Figure 37 Delay installation of PCC rules for a Preliminary AF Session

Steps 1–7 are similar to the ones explained in section AF Session Establishment. Next, the main differences are highlighted.

- 2. The SAPC receives an AAR message from the AF to establish a new AF session with the status of the service information provided by the AF, in the Service-Info-Status AVP, set to PRELIMINARY\_SERVICE\_INFORMATION, indicating that the service information that the AF has provided to the PCRF is preliminary and needs to be further negotiated between the two ends. NetLoc information may optionally be requested by the AF.
- 8. As the AF session is preliminary, the SAPC does not install any PCC rules and stores the Media Subcomponents received in step 2. It also stores that NetLoc information is pending, if requested in step 2.
- 9. The SAPC receives an AAR message from the AF to modify an existing AF session including the session identifier that identifies the AF session with the status of the service information provided by the AF, in the Service-Info-Status AVP, set to PRELIMINARY\_SERVICE\_INFORMATION, indicating that the service information that the AF has provided to the PCRF is still preliminary and needs to be further negotiated between the two ends. NetLoc information may also optionally be requested by the AF.
- 10-11. If the SAPC identifies that the updated AF session contains new media components, the SAPC performs dynamic service classification and authorization.
- 12. The SAPC responds to the AF with an AA-Answer command indicating the operation result. If the request is successful, the Result-Code AVP is set to the value SUCCESS. If the request is unsuccessful, an error code is indicated.
- 13. As the AF session is still preliminary, the SAPC does not install any PCC rules yet and stores the Media Subcomponents received in steps 2 and 9. It also stores that NetLoc information is pending, if requested in steps 2 or 9.
- 14. The SAPC receives an AAR message from the AF to modify an existing AF session including the session identifier that identifies the AF session with the status of the service information provided by the AF, in the Service-Info-Status AVP, set to FINAL\_SERVICE\_INFORMATION, indicating that the service information that the AF has provided to the PCRF already negotiated between the two ends. NetLoc information may also optionally be requested by the AF.
- 15-16. If the SAPC identifies that the updated AF session contains new media components, the SAPC performs dynamic service classification and authorization.
- 17. The SAPC responds to the AF with an AA-Answer command indicating the operation result. If the request is successful, the Result-Code AVP is set to the value SUCCESS. If the request is unsuccessful, an error code is indicated.
- 18. The AF session is marked as final, so the SAPC installs the dynamic PCC rules generated for the stored Media Subcomponents received in steps 2, 9 and 14.



Steps 19–24 are similar to the ones explained in section AF Session Establishment, including NetLoc information if requested at this point or while the AF session was preliminary, as explained in section AF Session Creation or Modification to Add a Media Component.

**Note:** The SAPC requests the Network Provided Location Information when the first preliminary AF session becomes final. For scenarios with multiple AF sessions bound to the IP-CAN session, this means that the PCEF may send the Network Provided Location Information to the SAPC when some AF sessions are still preliminary. If that is the case, the SAPC forwards the location information to all the AF sessions that were waiting for it, regardless if they are preliminary or final.

#### 4.7.2

#### Reception of a Gx Event for a Preliminary AF Session

The following signalling flows show how the SAPC handles the reception of Gx events for IP-CAN sessions bound to AF sessions in preliminary state.

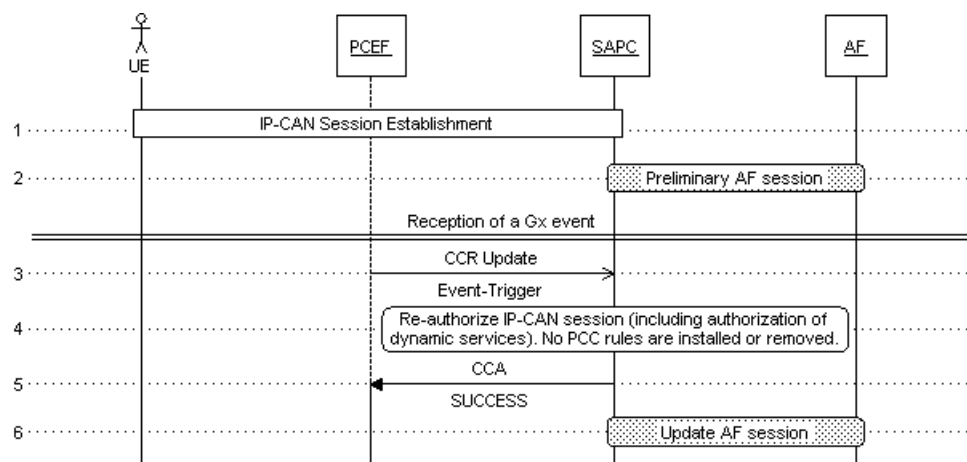


Figure 38 Reception of a Gx Event for a Preliminary AF Session

- 1 The UE has established an IP-CAN session.
- 2 The AF performs the session establishment procedure, as detailed in Section 4.1.1 on page 34.
- 3 The SAPC receives a CCR Update message from the PCEF indicating IP-CAN session modification, and the new/modified parameters together with the associated event-triggers.
- 4 The SAPC performs reauthorization of the IP-CAN session, including the reauthorization and qualification of all dynamic services running in the IP-CAN session, according to the applicable policies and the new information received.
- 5 The SAPC sends a CCA message to the PCEF, not including PCC rules for dynamic services with preliminary session information.



For step 6, the behaviour is similar to the one explained in section Reauthorization of Dynamic Services.

## 4.8 Dynamic Policy Control Error Handling

This section describes how the SAPC handles protocol errors and session failures.

Table 1 Error Handling

Error Condition	Action	Code
The SAPC receives an AAR and the corresponding IP-CAN session is not found, or more than one matching IP-CAN session is found.	The SAPC rejects the AF session establishment and returns an AAA indicating an error	Experimental-Result-Code AVP set to IP-CAN_SESSION_NOT_AVAILABLE 5065
The SAPC receives an AAR that cannot be complied owing to an internal error (for example, at reception of AAR-I and the associated IP-CAN session is being removed or doesn't exist after a PCEF request for CCR Termination).	The SAPC rejects the transaction and returns an AAA indicating an error	Result-Code AVP set to UNABLE_TO_COMPLY 5012
The SAPC receives an AAR with a mandatory parameter missed (for example the UE IP address in the AF session establishment)	The SAPC rejects the transaction and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_MISSING_AV P 5005





Error Condition	Action	Code
The SAPC receives an AAR-I with AF's subscription to notification of signalling path status, including the Media-Component-Description AVP (Media-Component-Number = 0, Media-Sub-Component (Flow-Number=0, Flow-Usage=AF_SIGNALLING)), but not including any Specific-Action AVP	The SAPC rejects the subscription and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_MISSING_AV P 5005
The SAPC receives an AF session establishment request with Rx interface Release 7 standard	The SAPC rejects the AF session establishment and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_MISSING_AV P 5005
The SAPC receives an AF session establishment request with Rx interface Release 8 standard	The SAPC rejects the AF session establishment and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_INVALID_AV P_VALUE 5004



Error Condition	Action	Code
The SAPC receives an AAR-I with AF's subscription to notification of signalling path status, including the Media-Component-Description AVP (Media-Component-Number = 0, Media-Sub-Component (Flow-Number=0, Flow-Usage=AF_SIGNALLING)) and the Specific-Action AVP, but the Specific-Action AVP not including value INDICATION_OF_RELEASE_OF_BEARE	The SAPC rejects the subscription and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_INVALID_AVP_VALUE 5004
The SAPC receives an AAR with the Rx-Request-Type AVP set to UPDATE_REQUEST (1) but the SAPC does not have an existing Rx session to be modified.	The SAPC rejects the transaction and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_UNKNOWN_SESSION_ID 5002
The SAPC receives an AAR with the Rx-Request-Type AVP set to PCSCF_RESORTATION (2).	The SAPC rejects the transaction and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_INVALID_AVP_VALUE 5004
The SAPC receives an STR and the AF session is not found (although the IP-CAN session exists)	The SAPC returns a STA indicating an error	Result-Code AVP set to DIAMETER_UNKNOWN_SESSION_ID 5002
The SAPC receives an AAR and the corresponding service is not authorized	The SAPC rejects the transaction and returns an AAA indicating an error	Experimental-Result-Code AVP set to REQUESTED_SERVICE_NOT_AUTHORIZED 5063



Error Condition	Action	Code
The SAPC receives an AAR with new media information and no dynamic service is successfully classified	The SAPC rejects the AF session establishment or modification and returns an AAA indicating an error	Experimental-Result-Code AVP set to REQUESTED_SERVICE_NOT_AUTHORIZED 5063
The SAPC receives an AAR-I requesting subscription to notification of signalling path status and the AF signalling profile is provisioned, but there are several services defined for the APN of the bound Gx session	The SAPC rejects the subscription and returns an AAA indicating an error	Experimental-Result-Code AVP set to REQUESTED_SERVICE_NOT_AUTHORIZED 5063
The SAPC receives an AAR-I requesting subscription to notification of signalling path status and the AF signalling profile is provisioned, but no service is found for the received APN and no default service is configured in the AF signalling path profile	The SAPC rejects the subscription and returns an AAA indicating an error	Experimental-Result-Code AVP set to REQUESTED_SERVICE_NOT_AUTHORIZED 5063
The SAPC receives an AAR-I requesting subscription to notification of signalling path status and the AF signalling profile is provisioned, but the selected service (based on APN or the default service) is not provisioned in the SAPC	The SAPC rejects the subscription and returns an AAA indicating an error	Experimental-Result-Code AVP set to REQUESTED_SERVICE_NOT_AUTHORIZED 5063



Error Condition	Action	Code
The SAPC receives an AAR to remove a media component and the AF session is not found.	The SAPC rejects the AF session establishment and returns an AAA indicating an error	Result-Code AVP set to DIAMETER_UNKNOWN_SESSION_ID 5002
The SAPC receives a DIAMETER_UNKNOWN_SESSION_ID error result in the Rx RAA message from the AF	The SAPC deletes the AF session and sends a Gx RAR message towards PCEF to remove the corresponding PCC rules	
The SAPC receives any error result in the ASA message from the AF	The SAPC deletes the AF session	
The SAPC receives a DIAMETER_UNKNOWN_SESSION_ID error result in the Gx RAA message from the PCEF	The SAPC deletes the IP-CAN session, and terminates the related AF sessions by sending an ASR command.	DIAMETER_AUTHORIZATION_REJECTED = 5003



## Reference List

### Ericsson Documents

- [1] Access and Charging Control (Gx)
- [2] Availability and Scalability
- [3] Bearer QoS and Bandwidth Management
- [4] Rx Interface Description
- [5] Subscription and Policy Management

### Standards

- [6] Policy and Charging Control signalling flows and QoS parameter mapping, 3GPP TS 29.213.
- [7] IP Multimedia Subsystem (IMS) emergency sessions, 3GPP TS 23.167.
- [8] IMS Restoration Procedures, 3GPP TS 23.380.