

# Bearer QoS and Bandwidth Management

Ericsson Service-Aware Policy Controller

## FACILITY DESCRIPTION

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## **Abstract**

This document provides a description for the QoS Control and Bandwidth management in network deployments using Gx interface.



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# 1 Bearer QoS and Bandwidth Management Introduction

This document provides a description for the Bearer Quality of Service (QoS) Control and Bandwidth management in network the Ericsson Service-Aware Policy Controller (SAPC) deployments using Gx interface.





## 2 Bearer QoS and Bandwidth Management Function

### 2.1 Bearer QoS and Bandwidth Management Overview

#### 2.1.1 QoS Control for the Default Bearer

It provides the operator better control over the radio resources and network resources granted to an end user for the default bearer. QoS Control for the Default Bearer ensures the following:

- That the right bearer quality is employed for an end user using a specific service
- The adjustment of the QoS negotiated in the network, avoiding possible over or under dimensioning of its resources
- The QoS assigned to the default bearer agrees with the requirements established by the operator, based on subscriber profile and the authorized services that are carried over the bearer

#### 2.1.2 QoS Control for Network-Initiated Dedicated Bearers

Dedicated bearers are extra logical transmission paths that have a particular QoS characteristics and a set of filters that define which IP flows pass through the bearer. Network-initiated QoS control ensures the following:

- Good user experience while accessing services that use a varying bandwidth
- Means for operators to control and achieve a predictable service delivery
- Optimal use of network resources

#### 2.1.3 IP Flow Bandwidth Management

It allows the operator to perform throttling by limiting the bandwidth of single IP flows within a multi-service session. For example, operators can protect premium services limiting the bandwidth of non-premium services or limit the bandwidth of some services for certain subscribers.

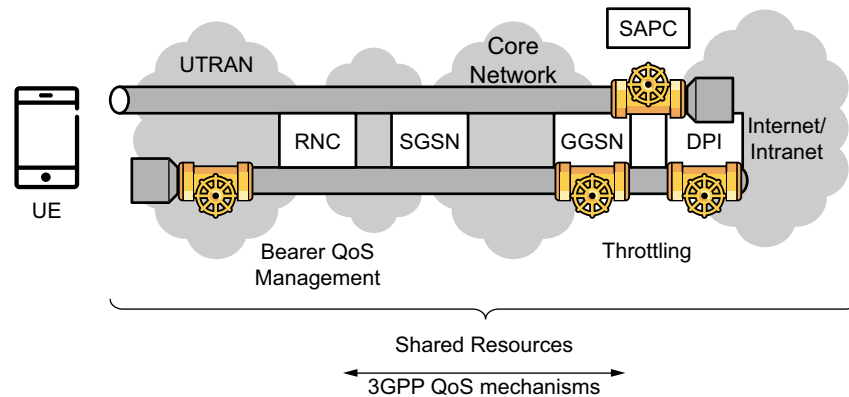


Figure 1 Bearer QoS and Bandwidth Management Network Elements in a 3GPP Network

Figure 1 shows the network elements involved in QoS control in a 3GPP network are the following:

- The GGSN/PDN GW
- The SGSN/MME
- The RNC that controls the uplink bandwidth and manages priority among radio resources.

The SAPC together with the GGSN/PDN GW provide Bandwidth Management (throttling).

The SAPC together with the GGSN/PDN GW provide bearer QoS management.

## 2.2 QoS in 3GPP Packet Networks

The term bearer is used to refer to an edge-to-edge association between the User Equipment and the traffic gateway. It is the level of granularity for bearer-level QoS control. It is the basic enabler for traffic separation, that is, it provides differential treatment for traffic with different QoS requirements. It identifies packet flows that receive a common QoS treatment between the terminal and the gateway. All packet flows mapped to the same bearer receive the same packet-forwarding treatment (for example scheduling policy, queue management policy, rate-shaping policy, link-layer configuration). Providing different packet flow treatment requires separate bearers.

For each PDN connection, one bearer exists per combination of QoS class and Allocation Retention Priority (ARP). The following two types of bearers exist:

- **Guaranteed Bit Rate (GBR) Bearer** (also called conversational bearer or streaming bearer): Admission control functions reserve GBR-related resources. Services using that GBR bearer can assume that congestion-related





packet losses (that is, packet losses caused by overflowing buffers) do not occur. A GBR bearer is generally established on demand because it blocks transmission resources by reserving them.

- **Non-GBR Bearer** (also called interactive bearer or background bearer): No transmission capacity is reserved for this bearer. Services running on a non-GBR bearer can experience congestion-related packet drops. A non-GBR bearer can remain established for long periods of time because it does not block transmission resources.

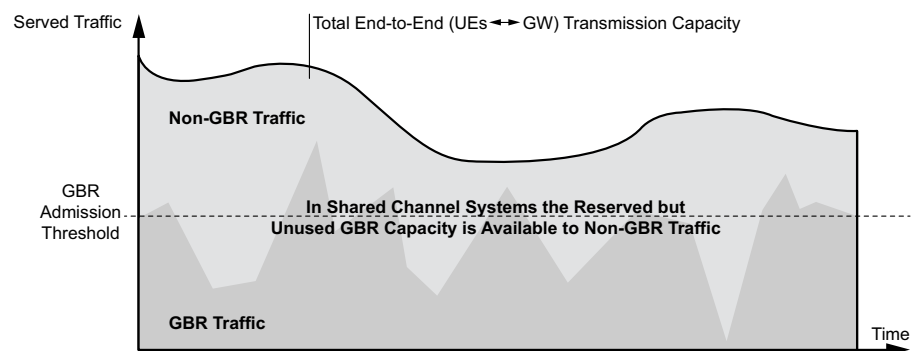


Figure 2 GBR vs Non-GBR Bearers

Figure 2 shows when a GBR is assigned to a certain traffic type, and the bit rate used by that service is lower than the assigned GBR, the unused bit rate can be assigned to other types of traffic. In case the bandwidth rate exceeds the GBR, such bandwidth is probably not assigned, and the corresponding traffic competes with the rest of the traffic.

A bearer is classified either as a default bearer or a dedicated bearer.

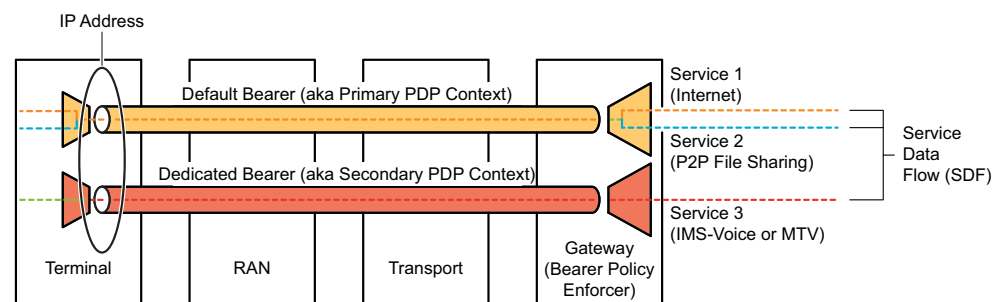


Figure 3 Default vs Dedicated Bearers

There is one **default** bearer (also called primary PDP context in GPRS terminology) per IP Address and APN (PDN connection) to provide basic connectivity. The default bearer is always a non-GBR bearer. Its QoS is initially assigned by the SGSN/MME based on subscription data provisioned in the HSS/HLR but it can be modified by the SAPC. The default bearer is typically associated with "matching all" Service Data Flows.

Providing different QoS in the RAN and transport network to different service flows for the same UE, requires one or more **dedicated** bearers (also called secondary PDP contexts in GPRS terminology). Dedicated bearers can be non-GBR or GBR bearers. The SAPC can request to initiate dedicated bearers based on static subscriber profiles or dynamic policy control conditions.

Figure 3 depicts a default bearer in yellow, and a dedicated bearer in red.

Multi-service single APN deployment strategy also requires several bearers per IP address to ensure the required differentiated QoS for different services. The SAPC is a key element for such cases because it can manage the network initiation of dedicated bearers.

### 2.2.1 QoS Parameters

This section describes the QoS parameters that the SAPC can change, and explains the purpose and intended use of the QoS parameters.

The QoS concept is class-based, where each bearer is assigned one QoS Class Identifier (QCI) and ARP by the network.

### 2.2.2 QoS Class Identifier (QCI)

The QCI is a scalar index that is used within the access network as a reference for parameters that control packet-forwarding treatment (scheduling weights, admission thresholds, queue management thresholds, link-layer protocol configuration). The QCI specifies the user-plane treatment that the packets carried on the associated bearer should receive.

The QCI refers to particular values of a set of QoS parameters such as **Traffic Handling Priority (THP)**, traffic class (that is, background, interactive, streaming, and conversational), and signaling indicator.

Table 1 shows the standardized QoS characteristics according to 3GPP TS 23.203 Reference [2].



Table 1 Standardized QCI Characteristics

QoS Class-Id entifier (QCI)	Resource Type	Packet Scheduling Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	GBR	2	100 ms	$10^{-2}$	Conversational Voice
2		4	150 ms	$10^{-3}$	Live Streaming Conversational Video
3		3	50 ms	$10^{-3}$	Real Time Gaming
4		5	300 ms	$10^{-6}$	Buffered Streaming Non-Conversational Video
65		0.7	75 ms	$10^{-2}$	Mission Critical user plane Push To Talk voice, for example MC-PTT
66		2	100 ms	$10^{-2}$	Non-Mission-Critical user plane Push To Talk voice
67		1.5	100 ms	$10^{-3}$	Mission Critical Video user plane
75		2.5	50 ms	$10^{-2}$	V2X messages
82		1.9	10 ms	$10^{-4}$	Discrete Automation - small packets
83		2.2	10 ms	$10^{-4}$	Discrete Automation - big packets
84		2.4	30 ms	$10^{-5}$	Intelligent Transport Systems
85		2.1	6 ms	$10^{-5}$	<ul style="list-style-type: none"> <li>High Voltage Electricity Distribution</li> <li>Remote Control</li> </ul>



QoS Class-Id Identifier (QCI)	Resource Type	Packet Scheduling Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
5	Non-GBR	1	100 ms	$10^{-6}$	IMS Signalling
6		6	300 ms	$10^{-6}$	<ul style="list-style-type: none"> <li>• Buffered Streaming Video</li> <li>• TCP-based services, for example internet, e-mail, chat, FTP, peer-to-peer file sharing, or progressive video</li> </ul>
7		7	100 ms	$10^{-3}$	Voice, Video (Live Streaming) Interactive Gaming <ul style="list-style-type: none"> <li>• Voice</li> <li>• Live Streaming Video</li> <li>• Interactive Gaming</li> </ul>
8		8	300 ms	$10^{-6}$	<ul style="list-style-type: none"> <li>• Buffered Streaming Video</li> <li>• TCP-based services, for example internet, e-mail, chat, FTP, peer-to-peer file sharing, or progressive video</li> </ul>
9		9			
69		0.5	60 ms	$10^{-6}$	Mission Critical delay sensitive signalling, for example MC-PTT signalling
70		5.5	200 ms	$10^{-6}$	Mission Critical Data, example services are the same as QCI 6, 8, and 9
79		6.5	50 ms	$10^{-2}$	V2X messages
80		6.8	10 ms	$10^{-6}$	<ul style="list-style-type: none"> <li>• Low latency TCP/UDP based eMBB applications</li> <li>• Augmented Reality</li> </ul>



QoS Class-Id Identifier (QCI)	Resource Type	Packet Scheduling Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
128-254	GBR or Non-GBR				Operator-specific QCIs
Any other value <254					As configured by the operator

**Note:** Packet Scheduling Priority, Packet Delay Budget, and Packet Error Loss Rate parameters are not handled by the SAPC.

The SAPC supports QCI values from 1 to 254, including the standard QCI values, and other QCI values that can be configured as either GBR or non-GBR.

For GBR bearers, transmission capacity is allocated in the network in advance to ensure a sufficient quality. These are Guaranteed Bit Rate (GBR) bearers, services that are using a bandwidth lower than the GBR can assume that congestion-related packet drops do not occur.

For non-GBR bearers, no capacity reservation is done, and congestion-related packet drops can occur. The Default bearer is always a non-GBR bearer with QCI values from 5 to 9.

### 2.2.3

#### Allocation Retention Priority (ARP)

It specifies the control-plane treatment that the bearers received. It defines the importance of a bearer compared to other bearers. It is used in case of congestion, to determine which Radio Access Bearer (RAB) needs to be dropped first. It can be used at bearer establishment or modification to decide which bearer to accept or to reject in case of resource limitations (typically GBR transmission capacity), or to decide which bearer or bearers to drop (bearer preemption) during exceptional resource limitations (for example, Target-RAN at handover). It consists of priority level, preemption capability indication, and preemption vulnerability indication.

The Priority-Level defines the relative importance of a resource request. The range of the ARP priority level is 1–15 with 1 as the highest level of priority. ARP priority levels 1–8 are recommended to be assigned to resources for the following:

- Emergency services
- Other services that are authorized to receive prioritized treatment within an operator domain

The Pre-emption Capability defines whether an SDF can get resources that were already assigned to another SDF with a lower priority level. The pre-emption capability is only applicable to EPS access.

The Pre-emption Vulnerability defines whether an SDF can lose the resources assigned to it to admit an SDF with higher priority level. The pre-emption vulnerability is only applicable to EPS access.

Both pre-emption capability and pre-emption vulnerability can take yes or no values.

#### 2.2.4 Maximum Bit Rate (MBR)

The MBR defines the upper uplink and downlink limit bit rate. MBR can be defined for an IP flow, or, in GPRS, for all the services running on the default bearer. With MBR restrictions, the full cell capacity is often not used.

#### 2.2.5 Guaranteed Bit Rate (GBR)

The GBR defines the uplink and downlink bit rate that is guaranteed for an IP flow. This parameter is only applicable to dedicated bearers, and not applicable if traffic class is interactive or background.

GBR is defined only for GBR bearers.

#### 2.2.6 Aggregate Maximum Bit Rate (APN-MBR)

In addition to QCI and ARP for the default bearer, the SAPC can control the **APN-AMBR**. APN-AMBR denotes the Aggregate Maximum Bit Rate, it limits the total bit rate that can be expected across all non-GBR bearers across all PDN connections towards the same APN for a UE. When a UE accesses an APN and a session is created, it is associated with an APN-AMBR value. The APN-AMBR can also be modified by the SAPC along IP-CAN session lifetime. It includes:

- Maximum requested bandwidth in uplink
- Maximum requested bandwidth in downlink

**Note:** In EPS accesses supporting dual connectivity (E-UTRAN and 5G NR), the SAPC is able to manage extended bit rates, that is bandwidth values higher than  $2^{32}-1$  bps. The extended bit rates over Gx is an optional function, and the SAPC negotiates its support during Gx session establishment (Extended-BW-NR feature).

When bandwidth values are higher than  $2^{32}-1$  bps:

- The Extended-Max-Requested-BW-UL AVP, expressed in kbps, is used instead of Max-Requested-Bandwidth-UL AVP
- The Extended-Max-Requested-BW-DL AVP, expressed in kbps, is used instead of Max-Requested-Bandwidth-DL AVP

See the protocol binding subsections in Section 5 on page 27.



All these parameters, QCI, ARP, MBR, GBR, and APN-AMBR can be modified by the SAPC, resulting in an upgraded or downgraded QoS compared with the QoS received by the GGSN/PDN GW from the HSS.

For example, in GRPS, when the SAPC downgrades or upgrades some of the QoS parameters, and sends them to the GGSN, the GGSN forwards the request to modify the QoS profile of the PDP context to the SGSN over the 3GPP Gn interface. The SGSN also forwards the request to modify the QoS profile associated with the Radio Access Bearer (RAB) over the 3GPP Iu interface towards the UTRAN. The UTRAN executes the QoS modifications that were ordered from the SAPC. Some examples of possible modifications are:

- Increase of the QCI value. When the cell is congested, the Radio Access Bearer (RAB) receives a lower priority on the radio interface. This translates to a lower bit rate when other users compete for the same radio resources
- Decrease in the MBR. This results in the reduction of the maximum bit rate in uplink and downlink direction over the RAB
- Decrease in the APN-AMBR. This results in the reduction of the maximum bit rate in uplink and downlink direction over a particular APN
- Decrease in the ARP. This results in the RAB receiving a lower priority in admission and congestion control algorithms. This translates into a higher likelihood of being blocked (that is, not getting access to the UTRAN) in situations when many users access the network
- Decrease of the QCI value. This results in the user experience being enhanced for bearers running premium services

## 2.2.7

### QoS Parameters for Network Initiated Dedicated Bearers in 3GPP Networks

The SAPC sends the authorized QoS per PCC rule that consists of a QCI, ARP for admission and congestion control, and MBR (uplink/downlink). For services requiring a Guaranteed Bit Rate, the QoS fields also include a GBR for uplink and downlink.

Upon reception of PCC rules including QoS from the SAPC, the PCEF performs the bearer binding, and evaluates whether it is possible to use one of the existing bearers or not, and whether to initiate bearer modification, if applicable. If it is not possible to use any of the existing bearers, the PCEF can initiate the establishment of a dedicated bearer.

The SAPC can decide at any time, based on the subscriber profile, that a PCC rule containing a new combination of the parameters **QCI and ARP** is needed. Therefore, the PCEF initiates a new bearer, that is, the process of installing this PCC rule triggers a new network-initiated bearer request from the enforcement point (GGSN or PDN-GW) towards the end user, in such a way that the end-user experience is enhanced (as dedicated bearers can be GBR-bearers).

An existing dedicated bearer can also be changed by modifying the corresponding PCC rules linked to that bearer.

Figure 4 shows an example of this behavior.

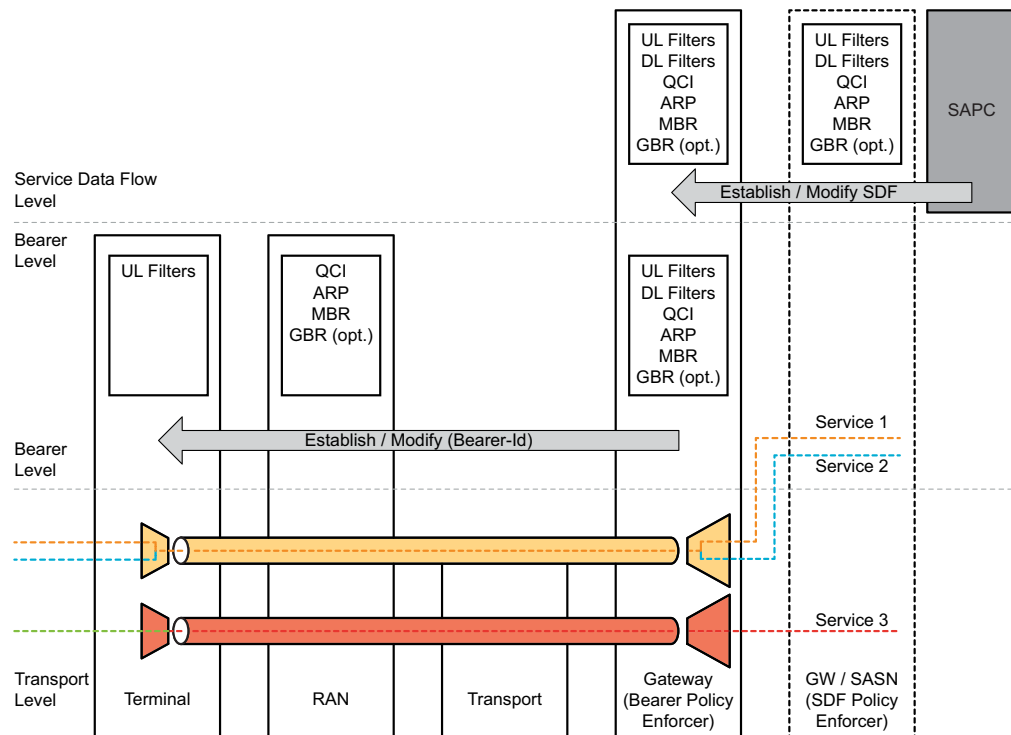


Figure 4 SAPC Orchestrating Dedicated Bearers

An example where the SAPC controls the QoS for preconfigured PCC rules using network initiated procedure is the case of assigning (for example changing the subscriber profile) a specific QoS Profile (containing QCI=5) for a preconfigured PCC rule representing IMS Signalling case.

## 2.3

### QoS Control for the Default Bearer and the APN

QoS Control for the Bearer and the APN decides the QoS parameters for the default bearer or primary PDP context and the QoS for the APN, that is, the APN-AMBR.

The SAPC ensures that the QoS assigned to the default bearer is in accordance with the operator requirements for the bearer and the authorized services that are running over the bearer.

The adjusted (authorized) QoS parameters to be returned to the PCEF are then in accordance with the subscription information, the bearer/network information received from the PCEF and the QoS requested.





The SAPC evaluates QoS Control for the Default Bearer and the APN at reception of:

- IP-CAN session establishment
- IP-CAN session reauthorization because of:
  - IP-CAN session modification
  - Update subscriber data. Refer to [Subscription and Policy Management](#)
  - Change owing to time conditions. Refer to [Subscription and Policy Management](#)
  - Changes owing to Fair Usage Control. Refer to [Fair Usage Control](#)
- Events received from the Application Function. For more details on Application Function, refer to [Dynamic Policy Control \(Rx\)](#)

At IP-CAN Session establishment or modification, the PCEF can send QoS parameters to the SAPC, that are requested by the UE. The QoS requested by the UE can be accepted, or modified by the SAPC, returning an authorized QoS to the PCEF.

The SAPC skips the QoS Control for the Default Bearer and the APN in the following cases:

- In GPRS scenarios, this procedure is only performed if the QoS negotiation is supported by the PCEF. It returns the requested QoS.
- If an event trigger related QoS modification failure is received, such as `DEFAULT-EPS-BEARER-QOS_MODIFICATION_FAILURE` or `APN-AMBR_MODIFICATION_FAILURE`, the requested QoS is accepted.

If the Bearer QoS Control is not configured for the requested PCEF, no QoS parameters are selected or sent to the PCEF for the default bearer in the IP-CAN session.

If the Bearer QoS Control is enabled for the requested PCEF, but there are no Bearer QoS Control policies configured, the SAPC accepts the QoS requested by the UE and returns the same values to the PCEF as the authorized QoS.

Figure 5 shows how the SAPC controls an authorized bearer QoS.

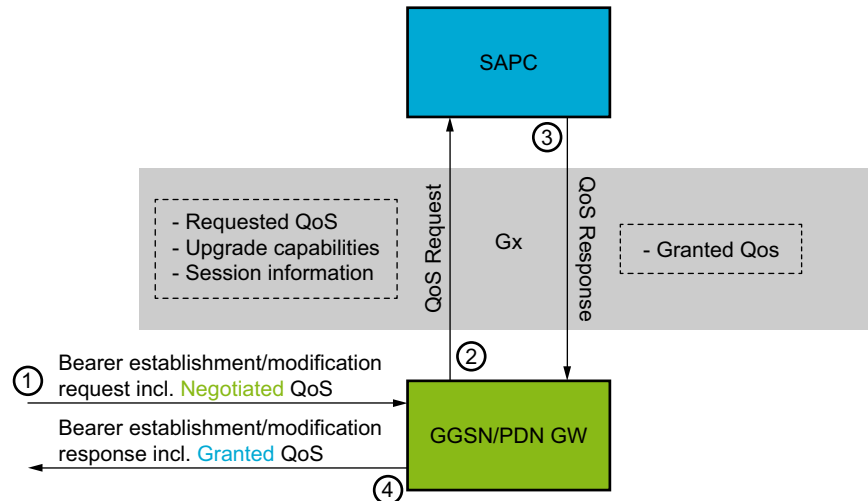


Figure 5 SAPC Controlling Authorized Bearer QoS

### 2.3.1 Detailed Procedure

QoS Control for the Default Bearer and the APN is executed by comparing the QoS profile received in the incoming Gx CCR messages with a QoS profile range required for the bearer and determined by the SAPC.

**Note:** If the PCEF does not include a proposed QoS, or when IP-CAN session reauthorization occurs because of subscriber profile update, the requested QoS is used for the QoS comparison as the authorized QoS assigned by the SAPC in the previous Gx interaction.

The SAPC then takes a decision on which QoS applies to the default bearer.

Figure 6 shows the SAPC calculates the QoS range for the default bearer using a maximum and minimum QoS profile selection. The QoS range is provisioned statically for a subscriber or group, or it is using configured QoS Control Policies for default Bearer or APN.

The SAPC determines the maximum and minimum QoS profile range to be applied to a subscriber applying the mechanism for controls using both conditional (policies) and unconditional (static) qualification data explained in "Selection of Data to apply to the Subscriber" section in *Subscription and Policy Management*.

Figure 6 shows how the SAPC defines the authorized QoS for the default bearer and the APN, representing the following decisions the SAPC can take:

- The SAPC returns QoSProfile 1 when the requested QoS profile is below the minimum QoS profile selected by the SAPC



- The SAPC returns QoSProfile 3 when the requested QoS profile surpassed the maximum QoS profile selected by the SAPC
- The SAPC accepts the requested QoS profile when it is above the minimum, but below the minimum QoS profiles selected by the SAPC

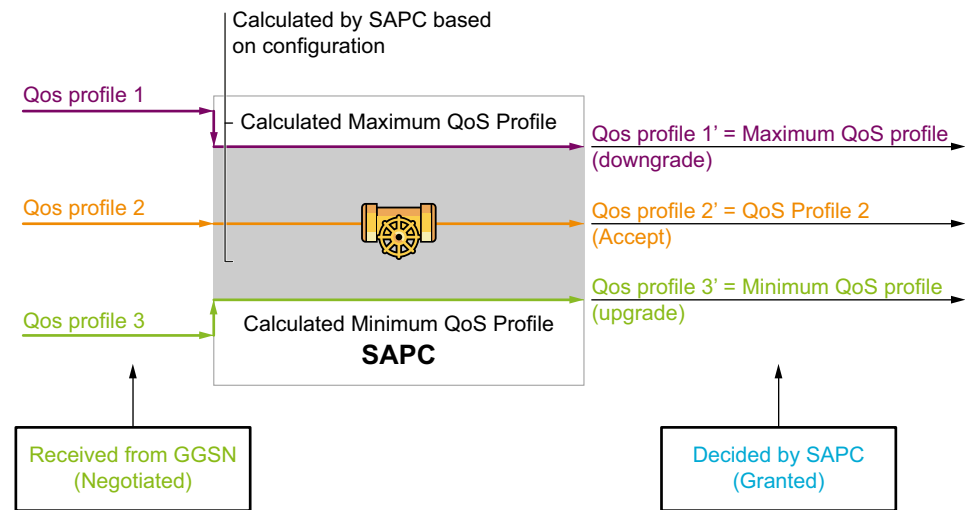


Figure 6 QoS Default Bearer Comparison

For further details on how the QoS profiles are compared, refer to Section 2.3.3 on page 17.

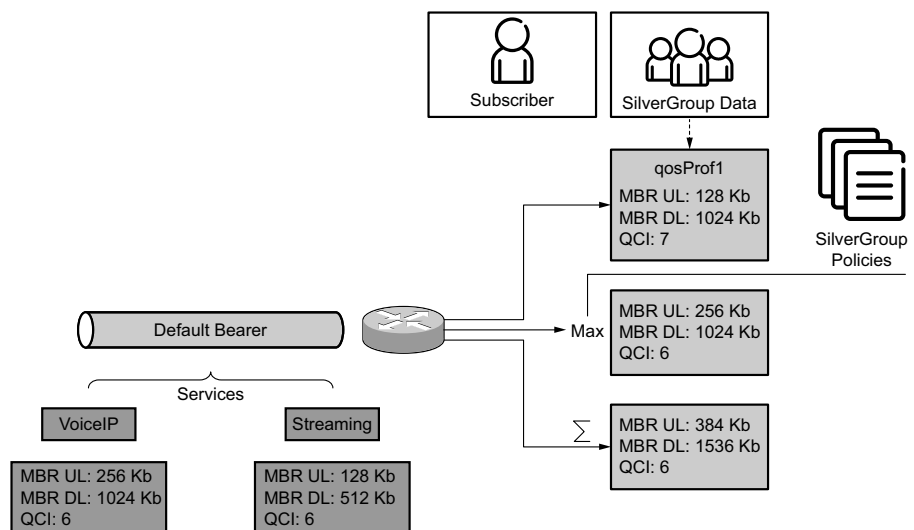


Figure 7 QoS for Default Bearer and the APN Data Model

QoS Control Policies for Default Bearer or APN can be used when dynamic conditions are needed to return maximum and minimum QoS profile values:



- A specific QoS profile identified by a name
- A QoS profile that is the result of a combination of a set of QoS profiles. The SAPC knows what services are authorized for the default bearer. Using QoS profiles statically assigned to services, or evaluating QoS for Service Policies for each one of these services, the SAPC obtains a set of QoS service profiles. For example, Figure 7 shows voiceIP and streaming service QoS profiles. Refer to Section 2.3.2 on page 16 for more information

Some functions and arithmetic operations (see details in ) can be used within QoS Control Policies for Default Bearer or APN, for example the **Max** or  $\Sigma$  in Figure 7 are assigned by using a SilverGroup policy to combine the service QoS profiles and obtain the authorized QoS for the default bearer and the APN. Refer to more information on functions in Section 2.3.2 on page 16

**Note:** Functions can only be used within QoS Control Policies for Default Bearer or APN, but not statically assigned to subscriber or subscriber group data.

## 2.3.2 Functions to Calculate QoS for the Default Bearer and QoS for APN

To define the applicable policies to obtain maximum and minimum QoS profiles, use the following functions:

- **Maximum QoS profile for pre-configured services:** This function returns a QoS profile composed of the highest value of QCI, ARP, and MBR of the values available for the authorized preconfigured services for the subscriber. The highest QCI means the lowest numeric value. The highest ARP means lowest numeric ARP priority level value. This function should be used when all the authorized services are configured to run in the default bearer. It ensures that the authorized service with highest MBR can run on the default bearer
- **Aggregated QoS profile for pre-configured services:** This function returns a QoS Profile composed of the addition of the MBRs out of the values available for the authorized preconfigured services for the subscriber. This function selects the highest value out of the QCI and ARP

This function ensures that all services can run in parallel. It should be used:

- If APN-AMBR is handled, when there are not authorized services configured to run on GBR bearers
- If MBR is handled instead of APN-AMBR, when all the authorized services are configured to run in the default bearer

Otherwise, the MBRs of dedicated bearers are also aggregated.

- **Maximum QoS for dynamic services,** refer to **Dynamic Policy Control (Rx)**. This function should be used when all the authorized dynamic services are configured to run in the default bearer. It ensures that the authorized dynamic service with highest MBR can run on the default bearer



- **Aggregated QoS for dynamic services**, refer to **Dynamic Policy Control (Rx)**. This function ensures that all dynamic services can run in parallel. It should be used:
  - If APN-AMBR is handled, when there are not authorized dynamic services configured to run on GBR bearers
  - If MBR is handled instead of APN-AMBR, when all the authorized dynamic services are configured to run in the default bearer

Depending on the deployment, the SAPC returns MBR or APN-AMBR (Qos for APN):

- If APN-AMBR is received from the PCEF, then APN-AMBR is returned from the SAPC
- If an MBR is received from the PCEF, then MBR is returned from the SAPC

### 2.3.3

#### Default Bearer QoS Profile Comparison

Once the maximum and the minimum QoS Profiles are determined for the general bearer, the SAPC compares such values with the QoS profile received in the incoming message.

The QoS comparison is done in the same way for all the supported Gx releases. However, the QoS attributes used for the comparison and the possible results provided by the SAPC are different for GPRS and EPS. See the protocol binding subsections in Section 5 on page 27.

The QoS profile is a structure composed of different fields. The comparison to determine which QoS profile applies to the bearer is done by comparing each field independently. For each field, if the QoS profile received in a CCR is higher than the configured maximum, then the QoS profile is considered as downgraded. If the QoS profile received in a CCR is lower than the configured minimum, then the QoS profile is considered as upgraded. If there is no configured value for a given field, the value received in a CCR is accepted.

To calculate the final QoS decision, the partial decisions are taken into account as follows:

- Accept: Only when all fields are accepted
- Upgrade: There is at least one field that needs upgrade, and no field needs downgrade
- Downgrade: There is at least one field that needs downgrade, and no field needs upgrade
- Upgrade & Downgrade (Change): There is at least one field that needs an upgrade and there is at least one field that needs a downgrade

## 2.4 QoS Control for Services

Using the SAPC, operators can control how each packet flow can be handled in terms of the QoS parameters.

QoS Control for services is performed at:

- IP-CAN session establishment
- IP-CAN session reauthorization because of:
  - IP-CAN session modification
  - Update subscriber data. Refer to [Subscription and Policy Management](#)
  - Change owing to time conditions. Refer to [Subscription and Policy Management](#)
  - Changes owing to Fair Usage Control. Refer to [Fair Usage Control](#)
- Events received from the Application Function (for more details refer to [Dynamic Policy Control \(Rx\)](#)).

### 2.4.1 QoS Control for Preconfigured PCC rules

The SAPC can send the authorized QoS for a PCC rule to the PCEF, using the PCC rule provisioning (installation or removal) procedure.

The SAPC allows this authorized QoS per SDF to control the QCI, ARP, MBR, and GBR for preconfigured PCC rules.

The adjusted QoS information returned to the PCEF is then in accordance with the following:

- Subscription information
- Bearer or network information received from the PCEF

The enforcement of the authorized QoS can lead the PCEF to request the network initiation or modification of dedicated bearers.

The SAPC can also assign and change the bandwidth limit for preconfigured PCC rules during the IP-CAN session lifetime. It enables the SAPC to control the peak uplink and downlink throughput of the services.

The SAPC determines the authorized QoS of each preconfigured PCC rule by evaluating the QoS for Service Policies applicable for it, for example VoiceIP service in Figure 8, according to the following precedence allocation:

- 1 Subject policy locator
- 2 Subject group policy locator. All the active subscriber groups are considered



Therefore it is recommended to configure Dynamic Group Selection policies to evaluate only the desired subscriber group policies

### 3 Global policy locator

If there are not applicable policies, or the policies are not fulfilled, the SAPC obtains the service QoS profile statically provisioned to the service, for example the VideoConference service in Figure 8.

**Note:** In relation to Network-Initiated dedicated bearer procedure, for which a particular QCI/ARP is needed, GBR can also be configured in the SAPC for preconfigured PCC rules, including it within a QoS Profile, in the same way as shown in Figure 8, provisioned for that Service.

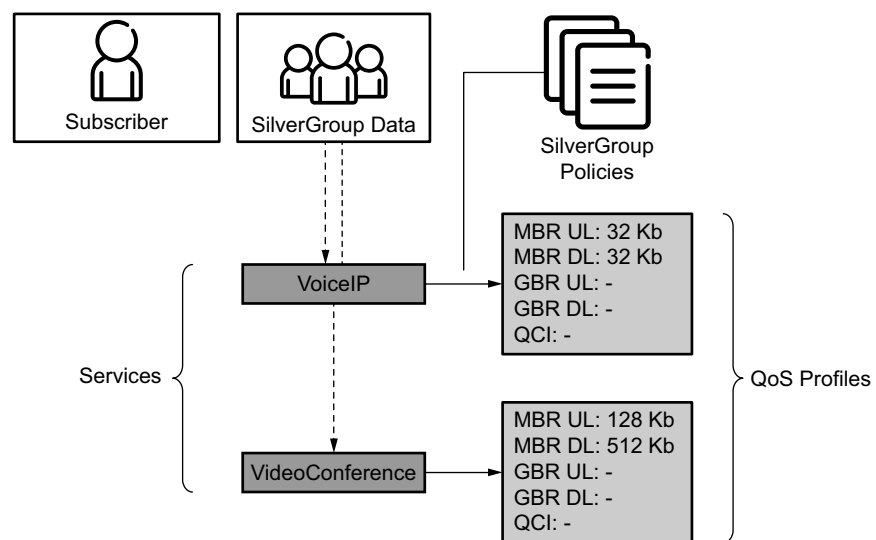


Figure 8 QoS for Services Data Model

For unidirectional services, i.e. those that only have defined either the uplink or downlink service data flow in the preconfigured PCC rules, the SAPC sets to zero the GBR/MBR in the direction where the data is not authorized, regardless of the value provisioned in the allocated QoS profile.

The SAPC does not allocate a GBR value to preconfigured PCC rules with QCI values 5-9, 69, 70 and 79, as those are 3GPP standard non-GBR services.

## 2.4.2

### QoS Control for Static PCC rules

The SAPC allows QoS control together with the PCEF by installation or removal of static PCC rules. The PCEF contains the mapping between the PCC rule name and its corresponding QoS information locally.

The SAPC selects the applicable PCC rules using Service Access Control, as described in Access and Charging Control (Gx).



### 2.4.3 IP Flow Bandwidth Management for Static PCC rules

The SAPC allows Bandwidth Management together with the PCEF by installation or removal of static PCC rules. The PCEF contains the mapping between the PCC rule name and its corresponding Bandwidth information locally, which may refer to a specific service, a set of services or the total traffic.

The SAPC selects the applicable PCC rules using Service Access Control, as described in [Access and Charging Control \(Gx\)](#).

### 2.4.4 QoS Control for Dynamic PCC rules

The SAPC can also perform QoS control for services that are dynamically negotiated taking into account information received from the Application Function (AF) over the Rx interface. This functionality is covered in [Dynamic Policy Control \(Rx\)](#).





## 3 Network Deployments

The SAPC can provide QoS for Bearer, QoS for APN and QoS for services in the following network deployments:

- Ericsson EPG using Ericsson Gx+ Rel9 onwards
- Standard 3GPP PCEF using standard Gx Rel9 onwards





## 4 Bearer QoS and Bandwidth Management Protocol Bindings

### 4.1 QoS Control for the Default Bearer and the APN

The following sections, contain the QoS related AVPs within Gx requests.

#### 4.1.1 Protocol Binding for standard Gx Rel9 onwards, GPRS Access

QoS Control for the Default Bearer and the APN is performed if the PCEF indicates that QoS Negotiation is possible (QoS-Negotiation AVP containing QoS\_NEGOTIATION\_SUPPORTED is received or QoS-Negotiation AVP not supplied) and QoS Control for the Default Bearer and the APN applies for the PCEF triggering the Gx message (configuration of the PCEF in the SAPC).

If QoS-Negotiation AVP containing No\_QoS\_NEGOTIATION is received together with QoS-Information AVP, the SAPC authorizes the requested QoS including in the answer message the received QoS-Information AVP.

**Note:** If the PCEF includes QoS-Information in the CCR containing at least QoS-Class-Identifier AVP, the SAPC performs QoS Control for the Default Bearer and the APN. If QoS-Information AVP is received in the CCR message without QoS-Class-Identifier AVP, the SAPC does not perform QoS Control for the Default Bearer and the APN and it does not answer QoS-Information AVP in CCA message.

The PCEF indicates if it supports QoS upgrades or not with QoS-Upgrade AVP:

- If no QoS-Upgrade AVP has been supplied by the PCEF, the default value QoS\_UPGRADE\_NOT\_SUPPORTED is applicable
- If the QoS-Upgrade AVP has been supplied in a previous CCR message but is not supplied in a new CCR during the same IP-CAN session, the previously supplied value remains applicable
- For reauthorizations initiated by the SAPC (for example because of update subscriber profile or time trigger), it considers that QoS\_UPGRADE\_SUPPORTED is applicable by default. The SAPC does not take into account the QoS-Upgrade AVP previously received for the session, since after an SGSN change, it cannot be ensured that a new CCR with QoS-Upgrade AVP is received from the new SGSN before the SAPC initiated reauthorization. Therefore, the previous QoS-Upgrade AVP received in CCR is not taken into account at reauthorizations initiated by the SAPC

For reauthorizations initiated by the SAPC, it considers that QoS Negotiation is possible by default.

#### 4.1.1.1 Accept, Upgrade, Downgrade

The fields that are compared are:

- QoS-Class-Identifier: values 1–9 are defined, being value 1 the highest class identifier
- MBR uplink
- MBR downlink
- ARP, Priority Level: values 1–15 are defined, being value 1 the highest level of priority
- APN-Aggregate-Max-Bitrate-UL
- APN-Aggregate-Max-Bitrate-DL

**Note:** MBR and APN-AMBR are mutually exclusive. If the PCEF sends MBR, then the SAPC answers with MBR; if the PCEF sends APN-AMBR, then the SAPC answers with APN-AMBR.

If the received QoS profile (QoS-Information AVP in the CCR) is within the calculated QoS range (higher or equal than minimum values, and lower or equal than maximum values), the SAPC **accepts** it and the received QoS-Information AVP is included in the CCA. The SAPC only includes the QoS-Information AVP in a CCA update message if at least one of the authorized QoS parameters differ from the values provided in a previous CCA or RAR message.

If the received QoS Profile is lower than the minimum QoS Profile, and QoS **upgrade** is supported (QoS-Upgrade AVP set to 1), the SAPC considers the value of the minimum QoS Profile to be included in the resulting QoS. In this case, the SAPC includes all QoS parameters in the QoS-Information AVP, not only those that need to be upgraded.

If the received QoS Profile is higher than the maximum QoS Profile, the SAPC considers the value of the maximum QoS Profile to be included in the resulting QoS. In this case, the SAPC includes all QoS parameters in the QoS-Information AVP, not only those that need to be downgraded.

**Note:** Some QoS elements can be upgraded and some other downgraded.

The received QoS profile is also **accepted**, when QoS upgrade is not supported (QoS-Upgrade AVP set to 0) and:

- The QCI received is lower than the QCI of the determined minimum QoS profile
- The QCI and ARP received are equal to the QCI and ARP of the determined minimum QoS profile but the MBR UL or MBR DL received are lower than the MBR UL or MBR DL of the determined minimum QoS profile



The QoS-Information AVP is mandatory in the CCR-Initial. If it is not received in the CCR-Update, the SAPC executes QoS Control for the Default Bearer and the APN taking into account the latest authorized QoS and APN sent by the SAPC.

#### 4.1.1.2 QoS Functions

Take into account some details when using QoS functions for the particular fields that compose QoS for standard Gx Rel9 onwards:

- Maximum QoS profile for pre-configured services:

The maximum **QCI** is the lowest numeric value

The maximum **Allocation-Retention-Priority, Priority-Level** is the lowest numeric value

#### 4.1.1.3 QoS Event Triggers

The SAPC can include the events that shall cause a re-request of PCC rules within Event-Trigger AVP. The list of requested events is provisioned. The following QoS related values are defined:

- QOS\_CHANGE (1) This value shall be used to indicate that upon a QoS change at bearer or APN level, PCC rules shall be requested. The QoS-Information AVP should be provided in the same request with the new value

**Note:** This event does need to be included if only QoS changes at APN level (APN-AMBR) are required. In such case, the PCEF always requests for PCC rules.

The SAPC can receive events informing about QoS modification failure. The following QoS related failure value is defined:

- APN-AMBR\_MODIFICATION\_FAILURE (29). The PCEF shall use this value to inform the SAPC that APN-AMBR modifications have failed. When the PCEF sends this failure value, it also sends the acceptable APN-AMBR in QoS Information AVP. No QoS Control for the Default Bearer and the APN is performed then by the SAPC

**Note:** This event is not included by the SAPC, since they are always reported by the PCEF.





## 5 Bearer QoS and Bandwidth Management Protocol Bindings

### 5.1 QoS Control for the Default Bearer and the APN

The following sections, contain the QoS related AVPs within Gx requests.

#### 5.1.1 Protocol Binding for standard Gx Rel9 onwards, GPRS Access

#### 5.1.2 Protocol Binding for standard Gx Rel9 onwards EPS

The requested QoS profile is received in CCR initial, within QoS-Information and Default-EPS-Bearer-QoS AVPs, see details in Table 2.

In EPS deployments, QoS upgrade or downgrade are always allowed (because of it the PCEF does not send information about whether QoS upgrade or downgrade is possible) therefore the SAPC considers that both options are possible.

If there are no Bearer QoS Control policies configured, the SAPC accepts the requested QoS from the PCEF, and returns the same values in the CCA initial

The SAPC only includes the QoS-Information and the Default-EPS-Bearer-QoS AVPs in a CCA update message if at least one of the authorized QoS parameters differ from the values provided in a previous CCA or RAR message.

##### 5.1.2.1 QoS Comparison

The fields that are compared are:

- QoS-Class-Identifier: values 1–254 are defined, being value 1 the highest class identifier
- APN-Aggregate-Max-Bitrate-UL or Extended-APN-AMBR-UL (mapped to MBR uplink)
- APN-Aggregate-Max-Bitrate-DL or Extended-APN-AMBR-DL (mapped to MBR downlink)
- ARP, Priority-Level: values 1–15 are defined, with value 1 as the highest level of priority
- ARP, Pre-emption-Capability: considering that DISABLED (true) value is greater than ENABLED (false)
- ARP, Pre-emption-Vulnerability: considering that DISABLED (true) value is greater than ENABLED (false)

Bandwidth values coming from Gx messages are taken from:

- Extended AVPs (Extended-APN-AMBR-UL and Extended-APN-AMBR-DL in kbps) when present and the extended bit rates over Gx function is supported and licensed.
- Non extended AVPs (APN-Aggregate-Max-Bitrate-UL, APN-Aggregate-Max-Bitrate-DL), in other cases.

Bandwidth values sent over Gx messages are set inside:

- Extended AVPs (Extended-APN-AMBR-UL and Extended-APN-AMBR-DL in kbps) when values are higher than  $2^{32}-1$  bps and the extended bit rates over Gx function is supported and licensed.
- Non extended AVPs (APN-Aggregate-Max-Bitrate-UL, APN-Aggregate-Max-Bitrate-DL), for other cases. When value is higher than  $2^{32}-1$  bps and the extended bit rates over Gx function is not supported or the function is not licensed, non extended AVPs are used and set to the maximum value supported, that is  $2^{32}-1$  bps.

If the received QoS-Information AVP is within the calculated QoS range (higher or equal than minimum values, and lower or equal than maximum values), the SAPC **accepts** it and the received QoS-Information AVP is included in the CCA.

If the received Default-EPS-Bearer-QoS AVP is within the calculated QoS range (higher or equal than minimum values, and lower or equal than maximum values), the SAPC **accepts** it and the received Default-EPS-Bearer-QoS AVP is included in the CCA.

If the received QoS parameters are lower than the minimum QoS Profile, the SAPC considers the value of the minimum QoS Profile to be included in the resulting QoS. The SAPC sends a CCA with all parameters of the minimum QoS profile when there is at least one field that needs downgrade, and no field needs upgrade.

If the received QoS Profile parameters are higher than the maximum QoS Profile, the SAPC considers the value of the maximum QoS Profile to be included in the resulting QoS. The SAPC sends a CCA with all parameters of the maximum QoS profile when there is at least one field that needs upgrade, and no field needs downgrade.

**Note:** Some QoS elements can be upgraded and some other downgraded: the SAPC can result in modify Default-EPS-Bearer-QoS, QoS-Information, or both by including these AVPs in CCA or RAR.

Default-EPS-Bearer-QoS AVP is composed of the QCI and the ARP.  
QoS-Information AVP is composed of the APN-AMBR.

Default-EPS-Bearer-QoS and QoS-Information AVPs are mandatory in CCR-Initial. If any of them is not received in the CCR-Update, the SAPC executes QoS Control for the Default Bearer and the APN taking into account the latest value sent by the SAPC.





### 5.1.2.2 QoS Event Triggers

The SAPC can include the events that shall cause a re-request of PCC rules within Event-Trigger AVP. The list of requested events is provisioned. The following QoS related values are defined:

- **DEFAULT\_EPS\_BEARER\_QOS\_CHANGE (20)** This value shall be used to indicate that upon a Default EPS Bearer QoS change, PCC rules shall be requested. The new value shall be provided in the Default-EPS-Bearer-QoS AVP
- **QOS\_CHANGE (1)** This value shall be used to indicate that upon a QoS change, at bearer level or APN level, PCC rules shall be requested. QoS-Information AVP should be provided in the same request with the new value

**Note:** The PCEF always requests for PCC rules when Default EPS Bearer QoS has changed, even if the event is not included by the SAPC

The SAPC can receive events informing about QoS modification failure. The following QoS related failure values are defined:

- **APN-AMBR\_MODIFICATION\_FAILURE (29)** The PCEF shall use this value to inform the SAPC that APN-AMBR modifications have failed. The PCEF retains the previous APN-AMBR value and includes the retained APN-AMBR in the QoS-Information AVP.
- **DEFAULT-EPS-BEARER-QOS\_MODIFICATION\_FAILURE (34)** The PCEF shall use this value to inform the SAPC that Default EPS Bearer modifications have failed. The PCEF retains the previous QoS parameters and includes the retained QoS values in the Default-EPS-Bearer-QoS AVP

**Note:** These events are not sent by the SAPC, since they are always reported by the PCEF.

### 5.1.3 Protocol Binding Summary

Table 2 Comparing QoS for GPRS and EPS Access

GPRS Access	EPS Access
IP-CAN-Type AVP = 3GPP-GPRS	IP-CAN-Type AVP = 3GPP-EPS
<b>Event Trigger</b>	
Event-Trigger AVP = QOS_CHANGE	Event-Trigger AVP = DEFAULT_EPS_BEARE R_QOS_CHANGE  Event-Trigger AVP = QOS_CHANGE
<b>QoS Negotiation</b>	
Qos-Negotiation AVP  QoS-Upgrade AVP	Negotiation and upgrade are always possible.
<b>Authorized Default Bearer QoS</b>	



Table 2 Comparing QoS for GPRS and EPS Access

GPRS Access		EPS Access
QoS-Information at command level, containing:		Default-EPS-Bearer-QoS at command level, containing:
<ul style="list-style-type: none"> <li>• QoS-Class-Identifier</li> <li>• Max-Requested-Bandwidth-UL</li> <li>• Max-Requested-Bandwidth-DL</li> <li>• Bearer-Identifier</li> <li>• Allocation-Retention-Priority</li> </ul>		<ul style="list-style-type: none"> <li>• QoS-Class-Identifier AVP corresponding to a non-GBR value, and</li> <li>• Allocation-Retention-Priority</li> </ul>
	Allocation-Retention-Priority contains	Allocation-Retention-Priority AVP contains:
	<ul style="list-style-type: none"> <li>• Priority-Level</li> </ul>	<ul style="list-style-type: none"> <li>• Priority-Level</li> <li>• Pre-emption-Capability</li> <li>• Pre-emption-Vulnerability</li> </ul>
APN Authorized QoS		
QoS-Information at command level contains:		QoS-Information at command level contains:
<ul style="list-style-type: none"> <li>• APN-Aggregate-Max-Bitrate-UL</li> <li>• APN-Aggregate-Max-Bitrate-DL</li> </ul>		<ul style="list-style-type: none"> <li>• APN-Aggregate-Max-Bitrate-UL</li> <li>• APN-Aggregate-Max-Bitrate-DL</li> <li>• Extended-APN-AMBR-UL</li> <li>• Extended-APN-AMBR-DL</li> </ul>
QoS errors		
Not applicable		Event-Trigger AVP = DEFAULT-EPS-BEARER-QOS_MODIFICATION_FAILURE
Event-Trigger AVP = APN-AMBR_MODIFICATION_FAILURE		Event-Trigger AVP = APN-AMBR_MODIFICATION_FAILURE

## 5.2 QoS Control for Services

This function is applicable for Ericsson Gx+ Rel9 onwards and for standard Gx Rel9 onwards, to GPRS and EPS scenarios.

### 5.2.1 QoS Control for Preconfigured and Dynamic PCC rules

QoS-Information AVP within Charging-Rule-Definition AVP contains the QoS parameters for preconfigured and dynamic PCC rules:



- Qos-Class-Identifier AVP contains the QCI assigned to the PCC rule
- Allocation-Retention-Priority AVP contains the ARP assigned to the PCC rule
- Max-Requested-Bandwidth-UL , Extended-Max-Requested-BW-UL, Max-Requested-Bandwidth-DL and Extended-Max-Requested-BW-DL contain the MBR assigned to the PCC rule
- Guaranteed-Bitrate-UL, Extended-GBR-UL, Guaranteed-Bitrate-DL and Extended-GBR-DL contain the GBR assigned to the PCC rule

Bandwidth values sent over Gx messages are set inside:

- Extended AVPs when values are higher than  $2^{32}-1$  bps and the extended bit rates over Gx function is supported and licensed.
- Non extended AVPs for other cases. When the bandwidth value is higher than  $2^{32}-1$  bps and the extended bit rates over Gx function is not supported or the function is not licensed, non extended AVPs are used and set to the maximum value supported, that is  $2^{32}-1$  bps.

## 5.2.2 QoS Control and IP Flow Bandwidth Management for Static PCC rules

Charging-Rule-Name AVP indicates the name of the static service to be installed (Charging-Rule-Install AVP) or to be removed (Charging-Rule-Remove AVP) in the GGSN/PDN GW

Within Charging-Rule-Install AVP, Rule-Activation-Time and Rule-Deactivation-Time AVPs are included by the SAPC in case time of day conditions are used within Service Authorization or Static Access policies and the PCEF is configured to control the time. For more details refer to [Access and Charging Control \(Gx\)](#).





# Reference List

## Standards

- [1] End-to-end Quality of Service (QoS) signalling flows, 3GPP TS 29.208
- [2] Policy and charging control architecture, 3GPP TS 23.203
- [3] Architecture enhancements for non-3GPP accesses, 3GPP TS 23.402
- [4] Policy and Charging Control (PCC) over Gx reference point, 3GPP TS 29.212