

# Subscriber Charging


- Feature Summary and Revision History, on page 1
- Feature Description, on page 2
- Mapping of Charging Scenario on Various Interfaces, on page 30
- Failure Handling Scenarios, on page 36
- Dynamic Update of Charging Configurations, on page 43
- Fetch Preemptive Quota with Static and Predefined Rules, on page 55


# Feature Summary and Revision History

## Summary Data

***Table 1: Summary Data***

| | |
|---|---|
| Applicable Products or Functional Area | SMF |
| Applicable Platforms | SMI |
| Feature Default Setting | • Subscriber Charging: Disabled – Configuration Required.<br>• Final Unit Indication for Gy Interface: Disabled – Configuration Required to Enable. |
| Related Changes in this Release | Not Applicable |
| Related Documentation | Not Applicable |

# Revision History

*Table 2: Revision History*

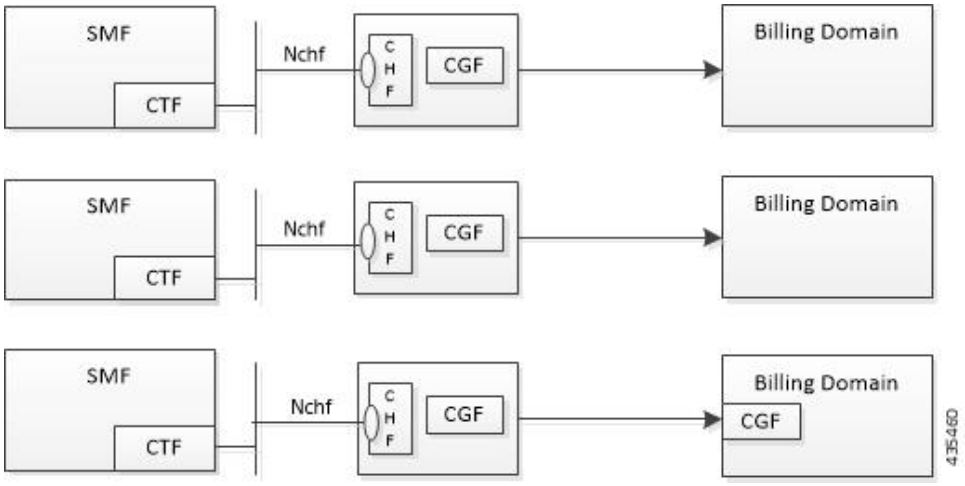
| Revision Details | Release |
|---|---|
| Added support for call-flow dictionary configuration, enhanced zero-usage URR suppression (online and offline), and new management-intervention-based usage reporting on rulebase changes and handovers. Includes detailed handling for inter/intra-PLMN handovers and trigger-based CDR reporting. | 2026.01.0 |
| Added Gz interface details for subscriber charging. | 2023.04.0 |
| Added support for the following features:<br>• Added the dynamic change in configuration of APN, ECS, and Charging profile.<br>• Gz Usage Report Handling with GTPP.<br>• Added Support for Final Unit Indication for Gy Interface. | 2023.03.0 |
| Added support for the following features:<br>• Charging Disable functionality<br>• Processing QoS Descriptor for Static and Predefined Rules | 2023.01.0 |
| Added support for extension in Charging Characteristics ID range values. | 2021.02.3.t3 |
| Added support for Query Interface IE. | 2021.02.0 |
| Introduced support for reconciliation of billing records when CHF is unreachable. | 2021.02.0 |
| Added session-level limitations on the N4 interface. | 2021.01.1 |
| Introduced support for the following:<br>• Zero Usage Report Suppression<br>• Dynamic ACS Configuration Change | 2021.01.0 |
| First introduced. | Pre-2020.02.0 |

# Feature Description

The SMF acts as a Charging Transfer Function (CTF). The CTF generates charging events toward the Charging Function (CHF), which is responsible for generating Charging Data Records (CDRs).

This SMF interacts with various interfaces, such as N40, Gy, N4, N7, and N10, facilitating charging in entirety. SMF uses the Nchf/N40 , Online Chargig System (OCS)/Gy , and Offline Charging System (OFCS)/Gz interfaces to generate charging events.

***Figure 1: SMF as a Charging Transfer Function***




The SMF Charging feature supports the following functionality.

- Converged Online and Offline charging.
- PDU session charging using the service-based interface.
- Network slice instance charging.
- Charging information collection per PDU session for UEs served under 3GPP and non-3GPP access (untrusted non-3GPP access, trusted non-3GPP access and wireline).

**Note** OCS/OFCS charging behaviour is applicable to the SMF 4G session when the SMF configuration has DNN profile with network element profiles for OCS/OFCS.

- Unique identity number assignment per PDU session for billing purposes.
- Separate count of data volumes on both the uplink and downlink directions. The data volumes reflect the data as delivered to and forwarded from the user.
- Charging mechanism that provides the date and time information when the PDU session starts.
- Handling of Charging Characteristics specific to a subscription or a subscribed DNN.
- Identification of data volumes, elapsed time, or events for individual service data flows (flow-based charging). One PCC rule identifies one service data flow.
- Usage reporting of a service, a detected application per rating group, or per combination of the rating group and service ID. You can activate this reporting level per PCC rule.
- Quota management only per Rating Group (RG) in case of N40, RG/RG+SID in the case of Gy/Gz per PDU session.

- Charging for IP-based PDU session types.

# Converged Charging

The 5G system supports converged charging for offline and online charging scenarios.

The SMF performs converged charging for each of the following:

- Charging data that is related to a PDU session.
- Charging data that is related to service-data flows within a PDU session.

The scope of convergent charging in this implementation includes quota management and usage reporting. For convergent charging, the SMF interacts with the CHF or OCS /OFCS for charging data related to PDU sessions. The Charging Data Request and the Charging Data Response messages are exchanged between the SMF and the CHF based on session-based charging (SCUR scenarios). The Charging Data Request is issued by the SMF only when conditions that are related to chargeable events are met.

## Chargeable Events

You can activate, deactivate, and modify PCC charging rules at any time during the PDU session lifetime.

PCF can modify the following attributes in a dynamic PCC rule active in the SMF:

- Charging Key
- Service Identifier
- Measurement Method

**Note** No modification is supported for Gy/Gz.

Activities on PCC rules and QoS flows aren't chargeable events. However, a change of charging rule in PCC rules leads to chargeable events. Some of the examples are the following:

- Start of service data flow.
- Termination of service data flow, for the last service data flow for the original PCC rule.

The charging key (that is, rating group) is used to request an online charging quota.

**Note** Depending on the reporting level received from the PCRF:

- For Gy, the quota is requested based on Rating Group (RG) or Rating Group and Service ID (RG+SID).
- For Gz, the quota is reported based on RG or RG+SID.

If no reporting level is received, then the quota is derived from rating group or service ID values received from the PCRF.

## Charging Identifier

The charging identifier correlates charging information between the SMF and CHF or OCS /OFCS during the duration of a PDU session. The SMF generates and assigns a charging identifier when a PDU session is established. The charging identifier is unique for that PDU session and is used in all messages that are exchanged in that PDU session.

## Charging information

***Table 3: Feature history***

| Feature name | Release information | Description |
|---|---|---|
| Introduction of nFFQDN IE in the nfConsumerIdentification message | 2026.01.0 | This feature introduces nFFQDN IE in the nfConsumerIdentification message that SMF sends to the CHF for subscriber charging. |

The SMF collects the following charging information for converged online and offline charging:

- **Usage of access and core network resources:** Describes the amount of data that is delivered to and forwarded from the UE.
- **Usage duration:** Time interval from PDU Session Establishment to PDU Session Release.
- **User:** UE information used by the user for a PDU session.
- **Data network:** Data network address as determined by the DNN.
- **Start time:** PDU session start time.
- **User location:** HPLMN and VPLMN reporting area.

**Note** SMF also sends nFFQDN IE as part of nfConsumerIdentification to the CHF.

For service-data flows (flow-based charging), the SMF collects the following information:

- PDU session description.
- Data that are transmitted in uplink and downlink directions based on the rating-group information, or a combination of rating-group and service ID during volume-based charging.
- Duration of service data flow based on the rating group, or a combination of rating-group and service ID during event-based charging.
- The number of events and corresponding time stamps categorized by rating group or combination of the rating group and service id when event based charging applies.

The SMF collects charging information for service data flows per UPF, within a PDU session, based on the rating-group or based on a combination of rating-group and service ID.

# How it Works

## Charging Session

The SMF supports converged session-based charging (SCUR) as specified in *3GPP TS 32.290, section 5.3.2.3*. If Gy is enabled, SMF supports session-based charging as specified in *3GPP TS32.299, 12.9.0 section 6.4*.If Gz is enabled, SMF supports session-based charging as specified in *3GPP TS32.298, 12.9.0 section 5.1.2.2*.

The SMF establishes a charging session with the CHF with the Charging Data Request and Response (Initial) exchange. During the life of the PDU session, usage is reported with a Charging Data Request or Response (Update) exchange. After the session is released, Charging Data Request or Response (Termination) messages are exchanged.

In the case of a 4G session when Gy is enabled, then SMF establishes charging session with OCS by sending credit control request and credit control response (initial) message exchange. During the PDU session, the usage is reported with credit control request and credit control response (update) messages. After the session release, credit control request and credit control response (terminate) messages are exchanged.

In the case of a 4G session when Gz enabled, then SMF creates the offline URRs, if dynamic PCC rule is received. Then, the SMF maps the PCC rule to the corresponding charging buckets (Service Data Flow (SDFs)) and sends the N4 Establishment Request towards CnPGW-U. During the life of PDU session, the usage is reported for offline SDF or Bearer-level URRs through N4 Session Report or in the N4 Delete Session Response from UPF, it may send the GTPP Data Record Transfer request towards GTPP.

## Offline Charging and Online Charging

***Table 4: Feature History***

| Feature Name | Release Information | Description |
|---|---|---|
| Gz support for subscriber charging | 2023.04 | You can enable Gz for 4G session so that SMF can send N4 Establishment Request with default Bearer Level URR and SDF Level URR in the case of dynamic rule. |

Charging is enabled for a session based on the input that is received from the PCF or PCRF.

For offline charging, the SMF sends Charging Data Request Initial toward the Charging Function (CHF) based on the presence of charging descriptors and refChgData field set in the smPolicyDecision message from the PCF in the SM Policy Control Create response.

On determining if charging is required during initial session establishment or post-session establishment, charging is enabled for the PDU session. Once charging is enabled, SMF sends the Charging Data Request (Initial) Message toward the CHF.

The SMF determines the Volume/Time threshold value either locally or from the Charging Data Response. These values are used to update the Volume/Time threshold IE in URR and to set the reporting trigger accordingly. The measurement method that is used in URR is derived from charging data.

For online charging, the SMF receives the Volume/Time Threshold and Quota values from the CHF. These values are received in the Charging Data Response (Initial) or using a Charging Data Request (Update) during a PDU Session Establishment. The SMF relays these Volume/Time Threshold and quota values to the UPF in the corresponding URR.

If Gy is enabled for an SMF 4G session, the session SMF sends the Credit Control Request (Initial) towards OCS to get the Volume/Time threshold and quota values. SMF relays these values towards to the UPF in the corresponding URR. If the SMF doesn't receive the volume threshold from OCS, the SMF determines the volume threshold from the local configuration.

If Gz is enabled for an SMF 4G session, SMF sends N4 Establishment Request with default Bearer Level URR and SDF Level URR in the case of dynamic rule. In the case of static and predefined rule, URRs are created after the PFCP session Report received with Start of Traffic (SoT). Bearer Level URR TIME_THRESHOLD and VOLUME_THRESHOLD values are received from egcdr threshold values that are configured in the Rulebase profile. SDF Level URR TIME_THRESHOLD and VOLUME_THRESHOLD values are received from egcdr threshold values that are configured in Charging profile. All the SDF Level URRs are linked to Bearer Level URR.

**Note** The threshold values from CHF always override the locally configured values.

The following table maps the IEs that are shared with the UPF during Create or Update URR during online or offline charging scenarios:

***Table 5: IE Mapping for Online and Offline Charging Scenarios***

| IE | Online | Offline | Derived From (N40) | Derived From Gy | Derived From Gz |
|---|---|---|---|---|---|
| Volume Limit | Yes | Yes | CHF Response or Local Configuration | OCS Response or Local Configuration | - |
| Time Limit | Yes | Yes | CHF Response or Local Configuration | OCS Response | - |
| Volume Quota | Yes | No | CHF Response | OCS Response | - |
| Time Quota | Yes | No | CHF Response | OCS Response | - |
| Quota Holding Time | Yes | — | CHF Response | OCS Response | - |
| Monitoring Time | Yes | Yes | • Local configuration for offline charging<br>• CHF response for online charging | OCS Response or Local Configuration | - |
| Reporting Trigger | Yes | Yes | The respective triggers that are set as shown in the following table. | OCS Response or Local Configuration | Local Configuration |
| Validity Time | Yes | - | - | OCS Response or Local Configuration | - |

The following table lists the reporting triggers and their derived source:

*Table 6: Reporting Triggers and the Derived Source*

| Reporting Trigger | Derived From N40 | Derived From Gy | Derived From Gz |
|---|---|---|---|
| Volume Threshold Trigger | If Volume threshold is set | OCS Response or Local Configuration | If Volume Threshold is set |
| Time Threshold Trigger | If Time threshold is set | OCS Response or Local Configuration | If Time Threshold is set |
| Volume Quota Trigger | If Quota Exhausted trigger is set from CHF | OCS Response or Local Configuration | - |
| Time Quota Trigger | If Quota Exhausted trigger is set from CHF | OCS Response or Local Configuration | - |
| Linked Usage Reporting (LIUSA) Trigger | If URR contains Linked URR | - | If URR contains Linked URR |

## Quota Management

The SMF requests quota from the CHF upon meeting any of the following conditions:

- The Rating Group (RG) is installed for the first time and the charging method is Online for the dynamic rule.
- The start of traffic trigger is initiated from the UPF for the RG in the case of static or predefined rules.
- A specific trigger type, as defined in the 3GPP specification 32.255, is received in the usage report for the online charging service from the UPF.

The SMF uses the **quota request always** CLI command to request the quota always. This CLI command is available in the Charging Profile configuration mode. Upon configuring this CLI command, the SMF always requests for quota when reporting the usage to the CHF for the online services. The quota requesting ends when the charging service stops.

Irrespective of the **quota request [ always | standard ]** CLI configuration, the quota request is disabled for the trigger type "qht" configured through the **quota suppress triggers** CLI command.

If Gy is enabled for a 4G session, SMF sends the Credit Control Request-Initial (CCR-I) message with the Requested Service Unit (RSU) attribute to OCS when the **send charging-initial** CLI command is configured as **on-receving-rule** and the **reqQuotaForDynRules** CLI command is configured as **session-start**. Only if the **send charging-initial** is available, the CCR-I message is sent without RSU. SMF sends the CCR-I message with RSU when session report received with start of traffic, if **charging-initial** and **reqQuotaForDynRules** CLI commands are configured as **traffic-start**. SMF requests for Quota based on the reporting level received from PCRF or based on the local configuration available in the Charging profile, which is either RG or RG+SID.

If Gy is enabled for a 4G session, SMF uses the following CLI commands in the Charging profile:

- **send charging-initial [session-start | traffic-Start]**

**Note** The default value is **session-start**.

- **dynamic-rules [request-quota on-receiving-rule | start-of-traffic]**

**Note** The default value is **on-receving-rule**.

### Service Units for Quota Management

The SMF sends Charging Data Record (CDR) to the Charging Function (CHF) for the service to be granted authorization to start, and to reserve the number of units. While triggering the CDR, the SMF requests volume (uplink, downlink, total) and time quota from CHF to support VoLTE and other use cases. The values of the requested units for static rules are obtained from the Diameter configuration under Active Charging Service. For the dynamic audio or video rules, the values for the requested service units are configured through the **requested-service-unit** CLI command in the Charging Profile Configuration mode.

**Note** If the Gz-enabled SMF interacts with OFCS to report usage, then Bearer Level and SDF Level values are received from the local egcdr configurations from rulebase and charging profiles respectively.

### Support for Validity Time

The SMF uses time quota value and its corresponding trigger on N4 interface to arm the UPF about the time when the SMF needs the reporting of validity time.

The CHF arms the SMF to report the usage for the rating group when the timer associated with the validity_time expires.

Based on the presence of Validity Quota and Time Quota, the SMF behaves as specified in the following ways:

- When the CHF sends only the Time Quota and not the Validity Quota, the SMF relays the CDR-U to the CHF and reports as Quota_EXHAUSTED upon receiving the usage report from the UPF.
- When the CHF sends only the Validity Quota and not the Time Quota, the SMF relays the CDR-U to the CHF and reports as VALIDITY_TIME upon receiving the usage report from the UPF.
- When the CHF sends both the Validity Quota and the Time Quota, the SMF determines the lower value of time_quota and validity_time, and then relays the CDR-U to the CHF accordingly. The SMF sends the "VALIDITY_TIME" trigger when the validity_time is lesser than the time_quota value. Similarly, when the validity_time is greater than the time_quota value, the SMF sends the "Quota_EXHAUSTED" trigger.

In addition to preceding behavior, the SMF sends Gy CCAU with one USU for volume and duration. For Gy, if the usage report is received with the volume and duration for the validity time, the SMF forwards the report to UPF.

## CHF Selection

The CHF selection can be performed through one of the following options:

1. PCF-provided one or more CHF addresses as part of the PCC rule
2. UDM-provided charging characteristics

3. NRF-based discovery
4. SMF locally provisioned charging characteristics

**Important** The SMF uses one of the last two options to fetch the CHF IP address and port details. The SMF initially performs NRF-based discovery to select the CHF server. If the SMF fails to identify the server, then it uses the locally provisioned charging characteristics. If Gy is enabled, SMF uses the locally configured Diameter client profile to connect with the OCS server.Similarly, if Gz is enabled, SMF uses the locally configured GTPP profile to connect with the Offline Charging System (OFCS) server.

## Charging Activities at SMF

URR Generation Toward N4

The SMF receives charging-data and usage-monitoring-data from the PCF. Based on this information, the SMF derives URR toward N4. In case the SMF is configured with volume/time limit at the session level, the SMF creates session-level URR.

### Handling of Initial Event in Charging Component

The session context of SMF is configured with trigger/threshold as per the default described in *3GPP TS 32.255*. It overrides the same based on configuration present in the charging profile. The same values can be further overridden by CHF Charging Data Response Initial. Currently, trigger/threshold cannot be overridden when in PDU Establishment state.

The charging profile is referenced from the charging-characteristic profile. The CC profile is taken from UDM subscription for PDU session. If the CC profile is not mentioned in the UDM response, it is taken from the DNN profile.

After trigger/threshold/quota are determined, the SMF N4 Setup Request with set of Create URRs are derived from charging-data with one session-level URR.

If the session-level reporting is determined, the session-level URR is associated to each SDF URR.

The following triggers are supported:

- Volume/Time trigger at session/RG level (N40) /RG or RG+SID level (Gy/Gz)
- AMBR change
- QoS change
- Quota threshold and quota exhausted
- Quota handling time
- Tariff time change

**Note** Gz supports Qos, ULI, and MsTimezone triggers only.

## Obtaining Threshold Values at SMF

Threshold values, during online charging, are always obtained from the CHF/OCS. In the case of Gy, if volume threshold is unavailable in the OCS response, the volume threshold is obtained from the local configuration. Whereas the threshold values, during offline charging, are obtained either from the CHF or from the charging profile configuration.

If charging profile is not determined during PDU establishment, the SMF refers to the charging profile from the DNN profile. Once the Charging Profile is determined, the SMF uses the determined Charging Profile to obtain the threshold values for Session/SDF URR.

In case of Gz, the Threshold values are received from rulebase for the Bearer Level URR and Charging profile from the SDF Level URR.

The configuration has threshold values at a session level or rating-group level. The rating-group level threshold values are generic and not about a rating-group. These threshold values are overwritten by CHF response.

The Gz interface supports the SDF-level configuration that is applied from the charging profile. This interface doesn't support the Rating Group level configuration.



**Note** The CHF response has various triggers. If some trigger is available at the session level or rating-group level, and if the volume or time threshold value is unavailable, then these values are assumed to be disabled at the corresponding level.

## Trigger Determination at SMF

The SMF has triggers enabled by default, as specified in 3GPP TS 32.255, section 5.2.1.4.

These triggers can be overwritten at a session level by trigger configurations present in the charging profile. Further, these triggers can also be overwritten by CHF/OCS responses.

Trigger configuration in charging profile is only applicable at a session level. It is not applicable for rating-groups. The trigger configuration is applicable at the SDF level.

In the case of Gz, the trigger configuration applicable to the SDF level URRs.

## Reporting Category

The charging trigger can be of two reporting categories—Immediate and Deferred. The usage report of the immediate category must be reported to the CHF immediately. For reporting events that must be deferred, the SMF stores the usage report locally, and publishes either when the next trigger of the immediate category is invoked, or when the storage limit is exhausted.

When reporting stored usage reports to the CHF, the usage report is triggered because of the trigger type in UsedUnitCategory and the message is triggered because of the trigger type in ChargingDataRequest.

Sometimes, a scenario can have two triggers hit at the same time. AMBR_Change and QoS Change can happen at the same time. In which case, all the triggers as applicable at the RG level or session level will have multiple trigger values. For OCS, all the triggers are applicable at MSCC level. For Gz, all the triggers are applicable at SDF level.

A trigger can be enabled at the RG level, and for some RG it can be immediate reporting and for others it can be deferred reporting. When a trigger event is hit, various usage reports will have a corresponding category filled respectively in usedUnitContainer.

Deferred CDR will be relayed in the following scenarios:

- An immediate category event happens.
- Maximum number of charging conditions are crossed.
- Configured number of maximum deferred reporting is crossed.

Maximum Charging Characteristics (CC) is reset whenever there are push CDRs. This could be because of maximum CC limits being crossed or because of immediate category reporting.

In case of Gz, CDRs are relayed based on the maxlosdb configuration in the charging profile.



**Note** Currently, SMF does not support two charging descriptors with the same rating group.

Only immediate reporting category is applicable in the case of Gy.

### *Handling Reporting Level*

The reporting category is classified into the following:

- Rating Group (RG) level: The RG is mandatory at this level.
- Service ID level: The RG and service ID is mandatory at this level.
- Sponsor ID level: The RG and Sponsor ID is mandatory at this level.

PCF communicates the reporting level to the SMF through the Charging Data Request. If the reporting level is RG, then RG is the primary key. If the reporting level is Service level or Sponsor Level, then RG and Service ID or RG and Sponsor ID respectively become the primary key. The SMF drops the charging descriptors from the PCF if the preceding requirement is not satisfied.



**Note** In the case of Gy or Gz, PCRF communicates the reporting level to SMF. If SMF receives no reporting level from PCRF, the reporting level is derived from the Rating Group or Service ID values received from the PCRF.

## Re-Authorization

The CHF triggers Reauthorization of charging descriptors using Charging Notify request. Reauthorization is implemented at the session-level or at a RG-level for both online and offline charging.

The SMF processes the reauthorization details (which contain an array of RG, ServiceId, QuotaMgmtIndicator) received in CHF Notify and retrieves the charging descriptors associated with the current PDU session. SMF ignores any unmatched reauthorization item.

For the charging descriptors identified for reauthorization, the SMF queries for usage reports from UPF and sends it to the CHF.

As part of the CHF response, the SMF detects any change in quota or threshold information and performs N4 Session Modification to update URRs.

## Final Unit Indication Support for N40 Interface

The SMF supports N40 Final Unit Indication (FUI) in the Charging Data Initial or Update Response from CHF as per 3GPP TS 32.291, section 6.1.6.2.1.12.

On receiving FUA, the SMF installs a new FAR and associates its FAR-ID in the URR, in the FAR ID Quota Action IE. If a FAR with the same parameters exists, the SMF uses its FAR-ID in the Create or Update URR. The UPF initiates appropriate actions set in FAR after quota exhaustion.

SMF supports FUI in CCA-I or CCA-U message from OCS. On receiving FUA, SMF installs a new FAR and associates its FAR-ID in the URR. If an FAR with the same parameters exists, SMF uses its FAR-ID in create or update URR. UPF initiates appropriate action as set in FAR after the quota exhaustion.

By default, the terminate configuration isn't activated to terminate the session and SMF only reports the final Used Service Unit to OCS without requesting further quota. UPF drops the further traffic after the quota exhaustion until OCS allocates the new quota through reauthorization.



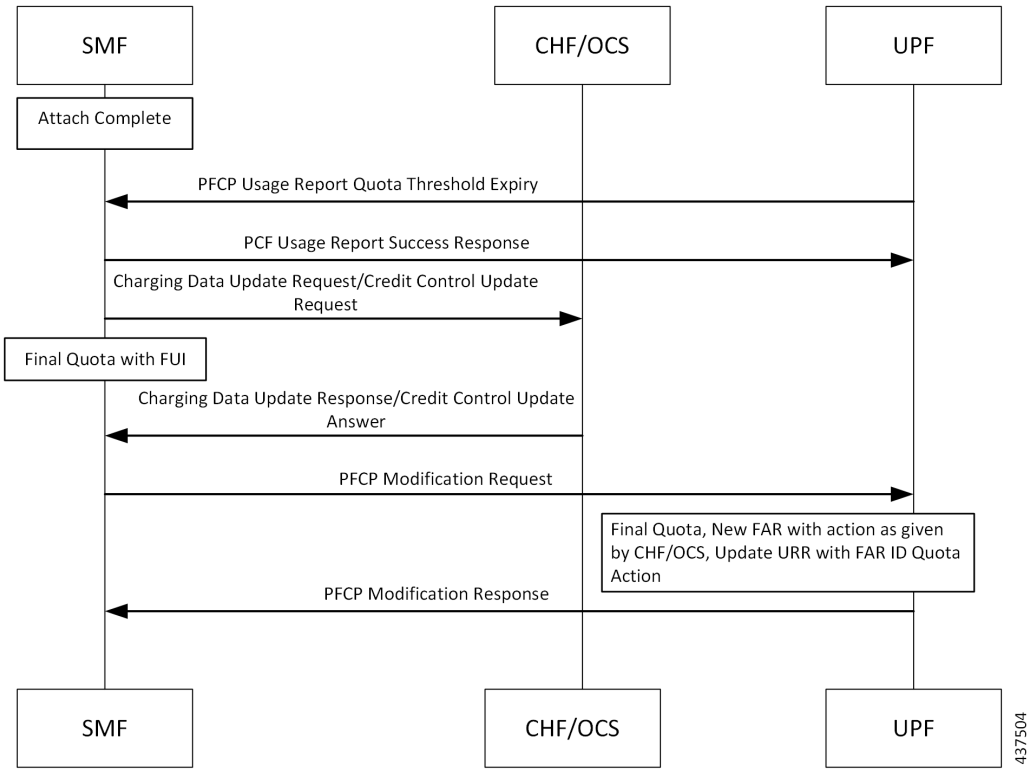
**Note** Reauthorization is supported for Gy.

FUI at MSCC Level—If FUI is received at the MSCC level and FUI CLI is configured to terminate the session, then SMF terminates the session if either the quota is exhausted or no quota is available.

FUI at Command Level—If FUI is received at the command level, then SMF terminates the session after quota is exhausted irrespective of FUI CLI configuration or no quota is available and FUI is received.

Currently, the SMF only supports Terminate and Redirect FU actions in the case of N40.

*Figure 2: FUI in the Charging Data Initial or Update Response from CHF*




- At any instance, CHF/OCS provides granted unit (Quota) to the SMF along with FUI.
- When the SMF receives the granted unit with FUI, the SMF creates FAR toward N4 and associates it to the corresponding URR which carries the quota information.
- After UPF receives the FAR associated with the URR, the corresponding FAR action is implemented when the quota exhausts.

## Final Unit Indication Support for Gy Interface

*Table 7: Feature History*

| Feature Name | Release Information | Description |
|---|---|---|
| Final Unit Indication (FUI) support in CCR-U | 2023.04 | As part of Gy Usage Reporting, SMF supports FUI in CCA-U from OCS.FUI is enabled or activated during the session creation or update. After FUI activation, when there is any update triggers due to an event trigger or Usage report, SMF sends subsequent CCR-U toward OCS without requesting further Quota and receives CCA-U. |

*Feature Description*

SMF supports Final Unit Indication (FUI) in Credit Control Answer-Initial (CCA-I)/Credit Control Answer-Update (CCA-U) from the Online Charging System (OCS) to indicate that the given quota is the final quota from the server and the corresponding action as specified in the AVP must be taken.

Upon receiving the Final Unit Action (FUA), the SMF installs a new Forwarding Action Rules (FAR) and associates its FAR-ID in Usage Reporting Rule (URR). If a FAR with the same parameters already exists, the SMF uses its FAR-ID in create/update URR. SMF takes an appropriate action as set in the FAR after the quota exhaustion.

In case of Final Unit Action terminate, the SMF installs a new FAR with the application action “drop” and associates its FAR-ID in URR. SMF terminates the Protocol Data Unit (PDU) session immediately after reporting the final Used-Service-Unit to OCS without requesting further quota, if configured to terminate the session and, the quota is exhausted for that service/MSCC regardless of the state of the other MSCCs.

If the usage report is received due to volume/time threshold or validity time, SMF reports the usage report only through Gy-CCR-U and continues to request for further quota.

By default, the terminate configuration is not activated to terminate the session and the SMF will only report the final Used Service Unit to OCS requesting further quota. SMF drops the further traffic after the quota exhaustion until OCS allocates the new quota through reauthorization.

Upon receiving a further quota from the OCS after FUI activation, the previous FUI gets overwritten.



**Note** Currently, the SMF with Gy interface supports only Terminate FU actions.

For FHT with Continue action, SMF terminates the PDU session immediately after receiving quota exhaustion for any FUI URR and reports the final usage to OCS through Gy-CCRT if CLI is configured to terminate the session or had received command level FUI. SMF sends Gy-CCRT to OCS with Termination Cause "DIAMETER-ADMINISTRATIVE" and MSCC Reporting reason as "FINAL".

When both time quota and validity time are received and the time quota exceeds validity time or when validity time alone is received without time quota, then SMF sends Gy-CCRU with MSCC reporting reason as "VALIDITY-TIME" and requests further quota.

### Levels of FUI

FUI exists at two levels:

- **Final Unit Indication at MSCC Level**: If FUI is received at the MSCC level then the SMF terminates the session after the quota exhausts, only if the FUI CLI is configured to terminate the session. Also, if there is no quota and FUI is received, the SMF terminates the session immediately, only if the FUI CLI is configured to terminate the session.
- **Final Unit Indication at Command Level**: If FUI is received at the Command level, the SMF terminates the session after quota exhaust irrespective of FUI CLI configuration. Also, if there is no quota and FUI is received, then the SMF terminates the session immediately.

### How it Works

FUI gets enabled or activated during the session creation or update. After FUI activation, when there is any update trigger due to an event trigger or Usage report, SMF sends subsequent CCR-U toward OCS without requesting further quota and receives CCA-U. Following scenarios can occur:

- **CCA-U receives with Quota and no FUI**: SMF resets the FUI, de-associates the FAR, and sends new quota in the update URR.
- **CCA-U receives with Quota and FUI**: SMF sends new quota in update URR, associates the previously dropped FARs, and continues with FUI without any update.
- **CCA-U receives without Quota and no FUI**: SMF does not send any updated URR and continues with the FUI without any update.
- **CCA-U receives without Quota and with FUI**:

  SMF terminates the session immediately

  - if the FUI is received at the command level and there is no quota
  - if the FUI is received at the MSCC level, the FUI CLI is configured to terminate the session, and there is no quota.

- **CCA-U receives with FHT action as Terminate**: SMF terminates the session immediately due to FHT.
- **CCA-U receives with FHT action as Continue and sub action as None/Unknown**:

  SMF allocates the maximum quota to both FUI and non-FUI online URRs regardless of whether the FUI is received at Command Level or at MSCC Level and **mscc-final-unit-action terminate session** CLI is configured or not.

- **CCA-U receives with MSCC Level Error**: SMF skips the failed MSCC and continues with the FUI without any update.

### *Limitations*

Following are the known limitations of the Final Unit Indication feature:

- Re-authorization is currently not supported in the FUI support for SMF with Gy interface.
- Redirection is currently not supported as part of FUI support for SMF with Gy interface.

### *Configuring Final Unit Indication*

To activate the Final Unit Indication, use the following sample configuration:

```
config
  profile charging profile_name
    mscc-final-unit-action terminate session
    end
```

**NOTES**:

- **mscc-final-unit-action terminate session**—By default, this configuration is not activated. If the Final-Unit-Indication AVP comes with an action TERMINATE for a given MSCC, the session will not be terminated by the SMF, and the UPF should take appropriate action for further traffic as set in FAR after the quota exhaustion. When the FUA in a particular MSCC is set as TERMINATE and the quota is exhausted for that service, the session will be terminated immediately regardless of the state of the other MSCCs.

## Configuration Verification

To verify the activation of FUI at MSCC level, use the following show command:

```
product smf(config)# show running-config profile charging chp
product smf(config-charging-chp)#
mscc-final-unit-action terminate session
```

*OAM Support*

Bulk Statistics Support

The SMF supports the following disconnect reason as part of **smf_disconnect_stats**:

- **disc_fua_terminate**—Session terminates due to Termination action of Final Unit Indication.

Following statistics is added as part of the **SMF Charging Final Unit Indication Stats Category**:

- **ocs_recieved_fui_stats counter**—Total number of Final Unit Indication received from OCS.

### Reconciliation of Billing Records



**Important** The Reconciliation of Billing Records is a customer-specific feature that requires IE level compliance across both the SMF and the CHF.

The communication of SMF and CHF involves both the converged CHF and offline CHF. When all the converged CHF servers are unreachable, the SMF falls back to the offline CHF for uninterrupted usage reporting. Then, the SMF sends the usage to the offline CHF.

The reporting to offline CHF does not include any differentiator in Used Unit Container (UUC) for the offline service and the converted offline service.

SMF supports a new enumerated value “CONVERTED_OFFLINE” in the Quota Management Indicator (QMI) added to the UUC. The SMF uses this enumerated value to mark the converted offline usage records sent to the offline CHF.

With this feature, the offline CHF server can differentiate between normal offline usage and converted usage records.

## Static and Predefined Rules for Charging

Configuration of static or predefined rules is similar to the procedures on SMF and UPF. The layout of configuration is as follows:

1. Rulebase: A one-to-many rulebase is configurable. For a single PDU session, you can activate a single rulebase any time. PCF can activate the rulebase at SMF by sending the rulebase name in the PCC rule.
2. Ruledef: Each rulebase can have one-to-many ruledef configurations. A ruledef can either be of static or predefined type. Each ruledef is assigned to a charging action.
3. Charging Action: Contains QoS and charging information.

The SMF derives charging data for each charging action in the rulebase. Charging action associated to static rules in the rulebase is immediately derived and updated in the PDU context. Charging action that is associated to predefined rules is derived and updated when PCF activates the specific predefined rule at SMF.

The charging action derived URR has the following behavior:

- Online charging is identified by the "**cca charging credit**" configuration under charging action.
- Offline charging is identified by the "**billing action egcdr**" configuration under charging action.
- Armed triggers for volume-limit and time-limit are under the gtpp group configuration, under APN. The UPF automatically detects these values and sends the respective usage reports. Gz uses triggers from the charging profile.
- The SMF, unlike the dynamic case, does not send the Create URR immediately for charging data that is derived from the configured rules.
- Using the online charging method, the UPF sends usage report with the "Start" trigger. The SMF uses CHF to derive the quota for the RG and relays the same information to the UPF in the Update URR message. In case of Gz, SMF reads the threshold values for Bearer Level URR from the rulebase and SDF Level URR threshold values from the Charging profile.
- You can configure the UPF threshold at a rulebase level. It creates a rulebase-level URR that is linked to all ruledef-level URR within the rulebase.

For a static rule, the SMF uses the active charging service configuration during run time to derive the QoS Descriptor information to be relayed towards CHF.

For predefined rules, the associated charging action results in creation of QoS Descriptor in session data with a combination of Rating Group (RG), service ID, and bandwidth ID values. When SMF relays the usage report to CHF, it checks for a match against the RG and service ID and uses the QoS that is applicable for the matched charging action.

**Important** If two predefined rules are simultaneously activated and the associated charging actions have the same RG and service ID but different bandwidth IDs, then the SMF checks if a match is found against the RG and service ID and uses the QoS that is applicable for the matched charging action. The SMF randomly selects the QoS Descriptor that is derived from one of the charging actions associated to the different predefined rules.

**Note** The preceding behavior is applicable to Gy as well.

## Modification Scenarios in Charging

### PCF/PRCF Update

The PCF performs the following actions during a modification scenario:

- Addition of PCC rules
- Modification of reference data
- Deletion of PCC rules
- Content update in charging data - using Measurement method

### CHF/OCS Response

The CHF response, during an exchange, sends updated volume and time thresholds and quota. The SMF relays the updated URR toward N4.

A change in threshold, trigger, or quota triggers an Update URR, which leads to the N4 relay.

SMF sends the Update URR based on the following triggers:

- Volume or time threshold
- Volume or time quota
- Tariff time change
- Quota holding time, and so on

### CDR Update for Immediate CC Events

The QUERY_INTERFACE IE supports sending the CDR message to the CHF for immediate CC events. If the CC trigger occurs at SMF and the trigger is armed at session level, the SMF queries the online and offline URRs at UPF, and the RADIUS URR if accounting is enabled. The QUERY_INTERFACE IE enables SMF to discover the URR that is available at UPF. This IE is configured along with the QUARR flag while sending the N4 Modification Request.

If the QUARR flag is not configured, the UPF does not report all URRs even if the QUERY_INTERFACE IE is configured. If QUARR flag is configured with the QUERY_INTERFACE IE, the Query URR will not be relayed to the UPF. This functionality is enabled or disabled using the **query-all-urr** CLI command in the Charging Profile configuration. By default, the configuration is enabled.

The QUERY_INTERFACE IE is a composite IE with bits for various interfaces.

The following flags are mapped to the specific URRs:

- GZ_Offline—Maps to interface 1 and UPF reports all offline SDF URRs.
- GY_Online—Maps to interface 7 and UPF reports all online SDF URRs.
- Radius_URR—Maps to interface 9 and UPF reports RADIUS URR.
- Bearer_URR—Maps to interface 2 and UPF reports all QBC URRs.
- Sess_URR—Maps to interface 12 and UPF reports Session level URR.



**Note** The **query-all-urr** CLI is not used for Gy or Gz.

Query interface is performed based on **query-all-urr** CLI for N40. However, the query interface is performed irrespective of CLI configuration for Gz and the query interface is not used for Gy.

## URR Linking

If you have configured session-level volume or time value locally or have received them from the CHF, the SMF creates session-level URR and links it to all URR corresponding to offline charging descriptors.

If PCF receives multiple charging descriptors that are of the same rating group, the SMF creates extra URR and links it to all URR derived from charging descriptors of the same rating group.

### URR Format

Following is the URR ID format:

- URR ID is 32-bit.
- MSB (32nd) bit for static or predefined URRs is configured to 1, and for dynamic URRs is configured to 0.
- First four LSB bits are configured for interface type.
  - 1 for offline
  - 7 for online
- Bit 4-31 is for URR ID number.

  For example: Dynamic first URR if ID is 1:

  0x00 00 01 01 Offline

  0x00 00 01 07 Online

  Static or Predefined first URR if ID is 1:

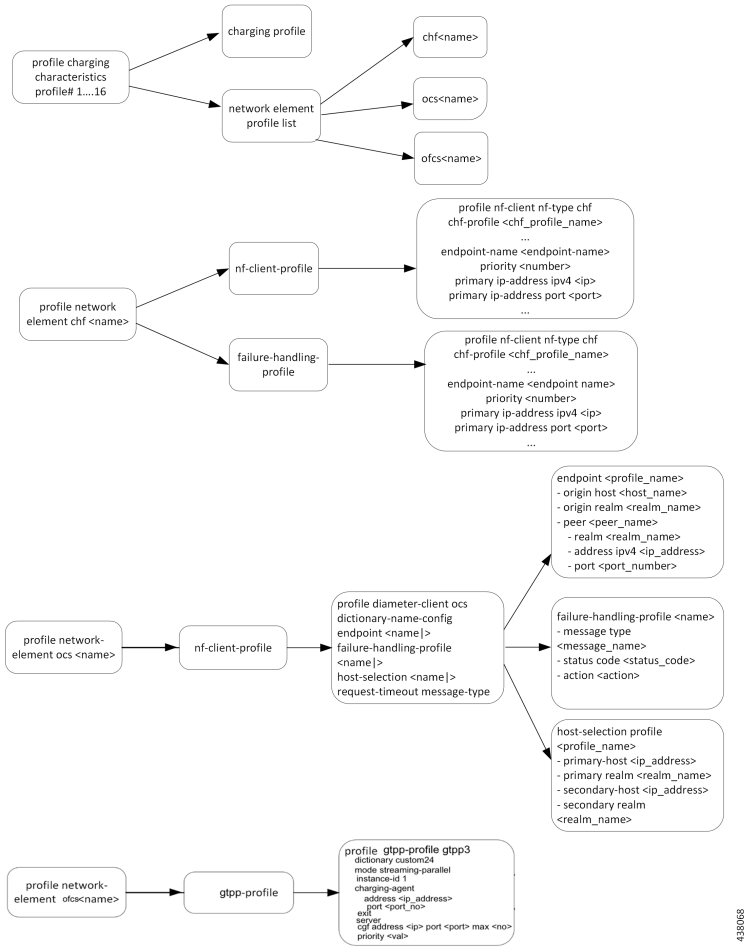
  0x80 00 01 01 Offline

  0x80 00 01 07 Online

## Local Configuration

The following figure illustrates how local configuration works.

***Figure 3: Local Configuration***




- The SMF supports up to 16 charging characteristic profiles.
- Each CC profile comprises charging group and charging profile.
- The charging server group and charging profile are linked to the DNN profile. Currently, the charging profile supports configuration for trigger and thresholds.

## Zero Usage Report Suppression

The SMF relays the offline resource usage report from the UPF to the CHF if any of the following conditions is met:

- Reporting type is immediate.
- Reporting type is deferred and the maximum number of deferred reportings is crossed.

The usage report includes the charging records with zero value as well. These zero value records (UUC and CDR-U) occupy unnecessary disk space on the CHF. To avoid this issue, the SMF leverages new configuration to control the offline charging records with zero byte data count.

When you configure the **offline zero-usage** CLI command in the Charging Profile configuration mode, the SMF relays the usage to the CHF without any overload of UUC or CDR-U.

The users can select the UUC or CDRs they want to suppress based on the CLI configuration.

**Important** The CDR release is never suppressed even if the **offline zero-usage drop cdr** command is configured in the Charging Profile configuration mode.

To support the zero suppress CDR, enable the **suppress-cdrs** CLI for Gz.

For details on the configuration, see the Charging Profile Configuration, on page 26 section.

# Call Flows

This section shows the following call flows:

## PDU Session Establishment

The following figure illustrates the call flow of PDU session establishment.

*Figure 4: PDU Session Establishment Call Flow*

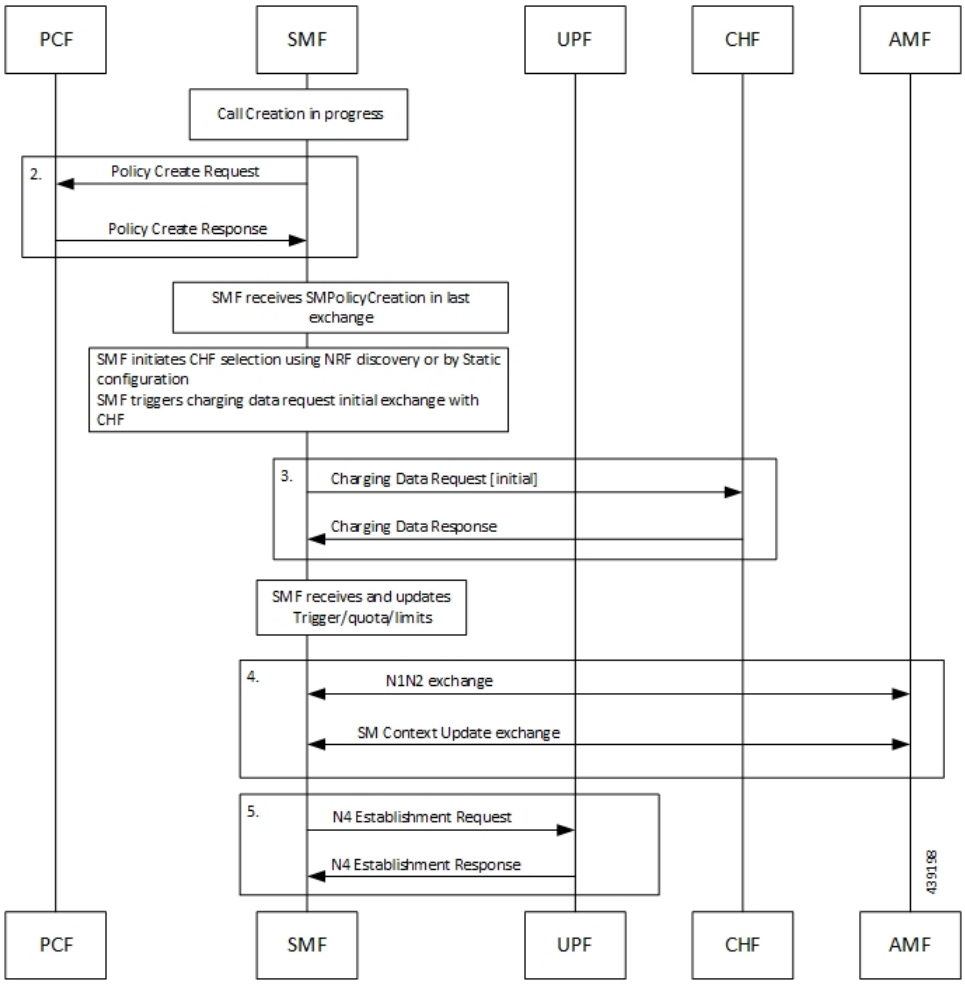



*Table 8: PDU Session Establishment Call Flow Description*

| Step | Description |
|---|---|
| 1. | Call creation starts at SMF. |
| 2. | SMF performs a Policy Create exchange with PCF. In this exchange, the SMF can receive Charging Data that is associated to a PCC Rule. This Charging data indicates that charging is enabled for the session in progress.<br>PCF may enable Static or Predefined rules. These rules can be also enabled with charging, based on the configuration. |

| Step | Description |
|---|---|
| 3. | After the charging is detected at SMF, SMF initiates a Charging Data Request Initial exchange with CHF. In this exchange SMF may receive the following information from CHF:<br>• CC triggers at session or RG level<br>• Session level Time or Volume limits<br>• Time or Volume limits at RG level<br>• Quota at RG level |
| 4. | SMF sends the N1N2 Exchange and SM Context Update Exchange to AMF. |
| 5. | SMF initiates N4 session establishment request exchange with UPF. In the same request, SMF relays the information related to charging in the Create URRs. |

## Limitations

The SMF Charging feature has the following limitations on the N4 interface:

- If the session-level URR (CDR-I) is created once, it remains active throughout the session. This URR is not deleted in the subsequent session (CDR-U).
- If the session-level URR is not created, then it is not created in the subsequent CDR-U even if the session limits are available.

# Standards Compliance

The SMF Charging feature complies with the following standards:

- *3GPP TS 32.255, version 15.3.0*
- *3GPP TS 32.290*
- *3GPP TS 32.299, version 12.9.0*
- *3GPP TS 32.298, version 12.9.0*

## 3GPP June 2019 Compliance for Charging Interface

The SMF is compliant with the 3GPP June 2019 specification TS 32.290 version 15.3.0.

For the June release, the messages goes over the version "v2" as indicated in the following URI format:

`nchf-convergedcharging/v2/chargingdata`

The CLI command for compliance configuration is: **service nchf-convergedcharging**. If this CLI command or version is not configured, the default version from 3GPP December 2018 is applied.

With the 3GPP June 2019 compliance, the following information elements (IE) are added:

- Authorized QoS
- Subscribed QoS
- IEs in QoSData

- Serving Network Function ID

# Configuring SMF Charging

The SMF Charging involves the following configurations:

- DNN Profile Configuration, on page 25
- Charging Characteristics Profile Configuration, on page 25
- Charging Profile Configuration

## DNN Profile Configuration

Use the following configuration to configure a DNN profile for SMF Charging.

```
config
  profile dnn profile_name
    charging-profile profile_name
    network-element-profiles [ chf profile_name | ocs profile_name ]
    end
```

**NOTES**:

- **charging-profile**: Specifies the Charging Profile configuration.
- **network-element-profiles**: Specifies the network element profile. Network element profile can be one of the following:

  **chf**: Specifies the CHF network element profile.

  **ocs**: Specifies the OCS network element profile.
- *profile_name*: Specifies the name of selected network element profile. After you select the network profile, enter a string.

## Charging Characteristics Profile Configuration

Use the following configuration to configure charging characteristics profile for SMF Charging.

```
config
  profile charging-characteristics cc_value
    charging-profile profile_name network-element-profile-list chf chf_name
    end
```

**NOTES**:

- *cc_value*: Specifies the charging characteristics value, which must be a 1 to 4 digit hexadecimal string in the range of 0x1 to 0xffff. For example, 11AB.

## Charging Characteristics ID Configuration

Use the following configuration to configure the charging characteristics ID, which is used to select the charging profile, if you have enabled the offline charging.

```
config
  profile dnn intershat charging-characteristics-id cc_id_value
    end
```

**NOTES**:

- **profile dnn intershat charging-characteristics-id** *cc_id_value*: Specify the charging characteristics ID value, which must be a 1 to 4 digit hexadecimal string in the range of 0x1 to 0xffff. For example, 11AB.

## Charging Profile Configuration

Use the following configuration to configure the charging profile parameters for SMF charging.

```
config
  profile charging profile_name
    limit [ rating-group ] { duration duration_value | volume volume_value }
    max-charging-condition max_cc_value
    max-deferred-urr max_urr_value
    method { none | offline | online }
    offline zero-usage [ drop { cdr | uuc } | measurement { duration |
volume } | trigger { external | final | internal } ]
    query-all-urr { false | true }
    quota request [ always | standard ]
    quota suppress triggers [ qht ]
    reporting-level { offline | online { [rating-group]
    | rating-group | service-id }
    requested-service-unit time seconds volume downlink downlink_value
    uplink uplink_value total total_value
    tight-interworking-mode { false | true }
    triggers session session_level_triggers
    session-failover { false | true }
    send charging-initial  { session-start | traffic-start }
    dynamic-rules request-quota { on-receiving-rule | on-traffic-match
}
    quota validity-time  validity_time
    quota volume-threshold percent  volume_threshold_percent
    usage-reporting quota-to-report based-on-grant {
report-only-granted-volume }
    mscc-final-unit-action terminate session
    max-secondary-rat-reports report_range
    egcdr losdv-max-containers container_num
    egcdr service-data-flow threshold { {volume | interval } { downlink
 | total | uplink }  bytes | {interval  <duration>}
    egcdr closure-reason { admin-disconnect | normal-release | }
    egcdr triggers {qos-change | uli-change | ms-timezone-change}
    egcdr suppress-cdrs zero-volume triggers { external-trigger-cdr
final-cdr  internal-trigger-cdr }
    egcdr-final-record closing-cause [ same-in-all-partials | unique ]
    end
```

**NOTES:**

- **limit**: Specifies the threshold limit.
- **duration**: Specifies the duration threshold for charging. The threshold value ranges from 0 through 2147483647.
- **volume**: Specifies the volume threshold for charging. The threshold value ranges from 0 through 9223372036854775807.
- **rating-group**: Specifies the volume and duration threshold for a Rating Group.
- **max-charging-condition** *max_cc_value*: Specifies the maximum number of changes to the charging condition. *max_cc_value* must be an integer ranging from 0 through 500. The default value is 20.
- **max-deferred-urr** *max_urr_value*: Specifies the maximum number of deferred USU containers. *max_urr_value* must be an integer ranging from 0 through 200. The default value is 50.
- **method**: Specifies the charging method. The default charging method is offline.
- **offline zero-usage { drop | measurement | trigger }** : The SMF suppresses the offline URR with zero volume and duration. By default, the zero usage drop configuration is disabled on SMF.
  - **drop { cdr | uuc }**: The SMF suppresses the CDR or UUC with zero usage. If there are mutiple reports, then the SMF drops only the reports with zero usage. Note that there is no impact on the online reporting.

    If the **drop** command is not configured, the SMF stops sending UUC for the offline usage report.
  - **measurement { duration | volume }**: The SMF specifies the measurement method of the network usage for suppression. The measurement method is based on volume and duration.

    If the **measurement** command is not configured, the SMF suppresses the records with both zero volume and zero duration, or the records with zero volume or zero duration depending on the configuration.
  - **trigger { external | final | internal }**: Specifies the list of triggers to be suppressed.
    - **external**: The SMF suppresses the usage reports that are generated due to external triggers, such as QoS Change, RAT change, User Location change, and PLMN Change.
    - **final**: The SMF suppresses the usage reports that are generated at the end of a context.
    - **internal**: The SMF suppresses the usage reports that are generated due to internal triggers such as, volume limit, time limit, and tariff change.
- **query-all-urr { false | true }**: Specify to query all URRs. By default, this configuration is enabled (set to true).

  If this CLI command is disabled (configured to false) or the CC trigger is not armed at session level, the SMF will send QUERY_URR and report CC events along with usage report.
- **quota request [ always | standard ]**: Controls the requesting of quota from the CHF for online charging services based on the configuration. If the **quota request always** is configured, the SMF always requests for quota. If the **no quota request** or **quota request standard** CLI command is configured, then the SMF requests the quota for specific trigger types as defined in standard, which is the default behaviour.
- **quota suppress triggers [ qht ]**: Suppresses the quota from the CHF upon configuring the usage report trigger type "qht".

- **reporting-level**: Specifies the reporting level configuration to be used for offline and online charging.

  The default value is [rating-group] level.
- **requested-service-unit**: Configures the value for the requested service units.
  - **time** *seconds*: Configures the time quota value in seconds from 1 through 4000000000.
  - **downlink** *downlink_value*: Configures the downlink volume in bytes from 1 through 4000000000.
  - **uplink** *uplink_value*: Configures the uplink volume in bytes from 1 through 4000000000.
  - **total** *total_value*: Configures the total volume in bytes from 1 through 4000000000.
- **tight-interworking-mode**: Configuration to enable tight interworking mode for online or offline charging methods.
- **triggers**: Specifies the list of triggers to be configured.
- **session** *session_level_triggers*: Specifies the list for Session Level Triggers. The list of Session Level Triggers is as follows:
  - **repor3gpp-ps-change**
  - **ambr-change**
  - **max-number-of-changes-in-charging-conditions**
  - **plmn-change**
  - **qos-change**
  - **rat-change**
  - **serv-node-change**
  - **tarrif-time-change**
  - **ue-pra-change**
  - **ue-time-change**
  - **upf-add**
  - **upf-rem**
  - **user-loc-change**
- **session-failover { false | true }**: Enable Diameter session failover for Gy. The default value of this configuration is **false**.
- **send charging-initial { session-start | traffic-start }**: Specify whether to send CCR-I message towards OCS when dynamic and predefined rules are received, otherwise CCR-I message sends the usage report received with the start of traffic. The default value is **session-start**.
- **dynamic-rules request-quota { on-receiving-rule | on-traffic-match }**: Specify whether to send CCR-I message with RSU when dynamic rules received, otherwise CCR-I message sends the usage report received with start of traffic along with RSU. The default value is **on-receiving-rule**.

- **quota validity-time** *validity_time*: Specify the validity lifetime of the quota in seconds 1 through 4000000.
- **quota volume-threshold percent** *volume_threshold_percent*: Specify the volume threshold value as a percentage of the volume quota 1 through 100.
- **usage-reporting quota-to-report based-on-grant { report-only-granted-volume }**: The **based-on-grant** option specifies the report volume or duration in Used Service Unit to OCS if only it is granted in Granted Service Unit by OCS server. The **report-only-granted-volume** option specifies the filter for sending Used Volume quota to OCS base on Input, Output, or Total Octets granted in Granted Service Unit by OCS server.
- **mscc-final-unit-action terminate session**: Terminate the session when MSCC final unit action is terminate.
- **max-secondary-rat-reports** *report_range*: Configure the maximum number of secondary RAT usage reports to trigger the GTPP (Gz) update. *report_range* must be an integer in the range of 0 to 50. The recommended value for secondary RAT usage limit for max-secondary-rat-reports is 25.
- **egcdr losdv-max-containers** *container_num*: Specify the maximum List of Service Data containers (LOSDV) for creating a GTPP data record. The default value is 1.
- **egcdr service-data-flow threshold { {volume | interval } { downlink | total | uplink }** *bytes* **| {interval** <*duration*>**}**: Specify the SDF level offline URR threshold values. The limit for the number of downlink, total, or uplink octets must be an integer in the range of 100000-4000000000.
  - **egcdr service-data-flow threshold interval***duration*: Configure the threshold for offline charging. The threshold interval value must be an integer in the range of 60–40000000.
- **egcdr closure-reason { admin-disconnect | normal-release | }**: Configure the closure reason.
- **egcdr triggers {qos-change | uli-change | ms-timezone-change}**: Enable the triggers for CDR.
- **egcdr suppress-cdrs zero-volume triggers { external-trigger-cdr final-cdr internal-trigger-cdr }**:
  - **egcdr suppress-cdrs zero-volume**: Suppress the CDRs.
  - **triggers**: Configure one of the list of triggers that can be used to suppress CDR with zero volume.
  - **egcdr suppress-cdrs zero-volume triggers internal-trigger-cdr**: Specify that an Async volume usage reporting is from UPF through PFCP session usage report.
  - **egcdr suppress-cdrs zero-volume triggers final-cdr internal-trigger-cdr**: Specify that a call is getting terminated.
  - **egcdr suppress-cdrs zero-volume triggers external-trigger-cdr**: Specify that a Sync volume usage reporting is from UPF through Query URR.
- **egcdr-final-record closing-cause [ same-in-all-partials | unique ]**
  - **egcdr-final-record**: Configure the final CDR.
  - **closing-cause [ same-in-all-partials | unique ]**: Configure the closing cause in case of the final CDR. The **same-in-all-partials** value specifies that the same closing cause is to be included for multiple final CDRs. The **unique** value specifies that the closing cause for final CDR is to be unique.

The following is a sample configuration for SMF Charging:

```
config
   profile dnn intershat1
   charging-profile chgprf1
   exit
   profile charging chgprf2
   limit volume 15000
   limit duration 90
   limit rating-group volume 12000
   limit rating-group duration 80
   triggers session [ ambr-change qos-change max-number-of-changes-in-charging-conditions
]
   max-charging-condition 1
   max-deferred-urr 3
   reporting-level online service-id
   reporting-level offline service-id
   session-failover   true
   quota validity-time 200
   quota volume-threshold percent 80
   dynamic-rules request-quota on-traffic-match
   send charging-initial traffic-start
   usage-reporting quotas-to-report based-on-grant
   mscc-final-unit-action terminate session
   max-secondary-rat-reports 25
   egcdr losdv-max-containers 2
   egcdr service-data-flow threshold volume downlink 100000
   cdr service-data-flow threshold interval 100
   egcdr closure-reason normal-release
   egcdr triggers ms-timezone-change
   egcdr suppress-cdrs zero-volume triggers
   egcdr-final-record closing-cause [ same-in-all-partials | unique ]

exit
```

# Mapping of Charging Scenario on Various Interfaces

## Feature Description

The charging functionality and behavior of the SMF is influenced by the parameters and messages received from the CHF, PCF, and UPF on the N40, N7 and N4 interfaces. Based on the charging data that SMF receives, it provides reporting level support for online and offline charging.

### How it Works

The SMF provides the different reporting levels for online and offline charging with the following rules:

- Configured rules are derived from the static or predefined charging actions.
- Session-level Usage Reporting Rule (URR) is derived from CHF trigger or local configuration.
- The SMF does not associate session-level URR for online and offline method charging description.
- The SMF does not associate session-level URR to the configured charging-action URRs.
- Rulebase URR is applicable only for the offline configured URR.
- For the configured online or online-offline charging method, if Ignore Service ID configuration exists, the URR list must contain "rg x urr-id y". Else, the SMF drops the charging actions as malformed.

**Important** The SMF supports multiple charging methods within the same rating group.

## Charging Mapping

The N7 interface uses Charging Data from PCC rules or local configuration, N4 interface uses URR or Packet Detection Rule (PDR), and N40 interface uses Used Unit Container (UUC).

The SMF charging mapping on N7, N4, and N40 interfaces with various charging methods is described as follows.

### *Offline Method When Charging Data is Derived from One PCC Rule*

Reporting level: Rating Group level or Service ID level

N4 interface:

- First URR is derived from the first Charging Data. Charging data limits from rating group trigger or local configuration.
- Second URR is derived from Session Limit, which is CHF or local configuration.
- Second URR is linked to the first URR.
- First PDR is derived from the first PCC rule.
- First and second URRs are linked to the first PDR.

N40 interface:

- First UUC is derived from the usage report of the first URR.
- First UUC may or may not have a service identifier.

**Note**

- Session-level URR is not associated to the configured URRs.
- If configured, rulebase URR replaces session-level URR.
- If configured and rulebase URR exists, it is linked to the first URR.

### *Online Method When Charging Data is Derived from One PCC Rule*

Reporting level: Service ID level or Rating Group level

N4 interface:

- First URR is derived from the first Charging Data, which is threshold or quota from rating group granted-unit.
- Second URR is derived from Session Limit, which is CHF or local configuration.
- Second URR is linked to the first URR.
- First PDR is derived from the first PCC rule.

- First and second URRs are linked to the first PDR.

N40 interface:

- First UUC is derived from the usage report of the first URR.
- First UUC may or may not have a service identifier.



**Note**

- Session-level URR is not associated to the configured URRs.

*Offline Method When Charging Data is Derived from Two PCC Rules*

Reporting level: Service ID level

N4 interface:

- First URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be LIUSA.
- Second URR is derived from the second Charging Data. Charging data has no limit and the rating trigger must be LIUSA.
- Third URR is derived from rating group level, which limits from Rating-Group trigger or local configuration.
- Fourth URR is derived from Session Limit, which is CHF or local configuration.
- The third and fourth URRs are linked to the first and second URRs.
- First PDR is derived from first PCC rule.
- Second PDR is derived from second PCC rule.
- First, third, and fourth URRs are linked to the first PDR.
- Second, third, and fourth URRs are linked to the second PDR.

N40 interface:

- First UUC is derived from the usage report of the first URR.
- Second UUC is derived from the usage report of the second URR.
- Both the first and the second UUCs have a service identifier.



**Note**

- Session-level URR is not associated to the configured URRs.
- If configured, rulebase URR is linked to the first and second URRs.

*Online Method When Charging Data is Derived from Two PCC Rules*

Reporting level: Service ID level

N4 interface:

- First URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be Linked Usage Reporting (LIUSA).
- Second URR is derived from the second Charging Data. Charging data has no limit and the rating trigger must be LIUSA.
- Third URR is derived from rating group level, which is threshold or quota from the rating group granted unit.
- Fourth URR is derived from Session Limit, which is CHF or local configuration.
- Third and fourth URRs are linked to the second and fourth URRs.
- First PDR is derived from the first PCC rule.
- Second PDR is derived from the second PCC rule.
- First, third, and fourth URRs are linked to the first PDR.
- Second, third, and fourth URRs are linked to the second PDR.

N40 interface:

- First UUC is derived from usage report of the first URR.
- Second UUC is derived from the usage report of the second URR.
- Both the first and the second UUCs have a service identifier.



**Note**

- Session-level URR is not associated to the configured URRs.
- If Ignore Service ID is configured, this method is not valid.

### *Offline-Online Method When Charging Data is Derived from One PCC Rule*

Reporting level: Service ID level or Rating Group level

N4 interface:

- Offline URR is derived from the first Charging Data, which limits rating group trigger or local configuration.
- Online URR is derived from the first Charging Data, which limits from the granted unit.
- First PDR is derived from the first PCC rule.
- Offline and online URRs are linked to the first PDR.

N40 interface:

- First UUC is derived from the usage report of the offline URR.
- Second UUC is derived from the usage report of the online URR.

*Offline-Online Method When Charging Data is Derived from Two PCC Rules*

Reporting level: Service ID level

N4 interface:

- First offline URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Off3.
    - Second offline URR is derived from the second Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Off3.
    - Third offline URR is the rating group level, which limits the rating group trigger or local configuration.
    - First online URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Online3.
    - Second online URR is derived from the second Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Online3.
    - Third online URR is the rating group level, which limits from the granted unit.
    - First PDR is derived from the first PCC rule.
    - Second PDR is derived from the second PCC rule.
    - First offline URR, first online URR, third offline URR, and third online URR are linked to the first PDR.
    - Second offline URR, third online URR, third offline URR, and third online URR are linked to the second PDR.

N40 interface:

- First UUC is derived from the usage report of the first offline URR and has a service identifier.
- Second UUC is derived from the usage report of the second offline URR and has a service identifier.
- Third UUC is derived from the usage report of the first online URR and has a service identifier.
- Fourth UUC is derived from the usage report of the second online URR and has a service identifier.

*Offline-Online Method When Charging Data is Derived from One PCC Rule with No Service Identifier*

The offline and online reporting levels are at Service ID and Rating Group levels respectively.

Prerequisite: No Reporting Level from PCF

- CLI:
    - Tight interworking mode
    - Ignore Service Identifier
    - Offline Reporting: Service Identifier
    - Online Reporting: Rating Group

**Note**

- The SMF ignores the volume or time limit trigger from CHF at the rating group level.
- Session-level URR is not associated to URRs that are derived from the first Charging Data.

N4 interface:

- Offline URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Online.
- Online URR is derived from the first Charging Data, which limits from the granted unit.
- First PDR is derived from the first PCC rule.
- Online URR and offline URR are linked to the first PDR.

N40 interface:

- First UUC is derived from the usage report of the offline URR and has a service identifier.
- Second UUC is derived from the usage report of the online URR and does not have a service identifier.

**Note**

- Session-level URR is not associated to the configured URRs.
- If URR is configured, URR rulebase is derived from eG-CDR and is linked to both the offline and the online URRs.

### *Offline-Online Method When Charging Data is Derived from Two PCC Rules with No Service Identifier*

The offline and online reporting levels are at Service ID and Rating Group levels respectively.

Prerequisite: No Reporting Level from PCF

- CLI:
  - Tight interworking mode
  - Ignore Service Identifier
  - Offline Reporting: Service Identifier
  - Online Reporting: Rating Group

**Note**

- The SMF ignores the volume or time limit trigger from CHF at the rating group level.
- Session-level URR is not associated to URRs that are derived from the first Charging Data.

N4 interface:

- First offline URR is derived from the first Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Online.
- Second online URR is derived from the second Charging Data. Charging data has no limit and the rating trigger must be LIUSA. Charging data has the linked URR ID as URR_Online.
- URR_Online is derived from the second Charging Data, which limits from the granted unit.
- First PDR is derived from the first PCC rule.
- Second PDR is derived from the second PCC rule.
- First offline URR and URR_Online are linked to the first PDR.
- Second offline URR and URR_Online are linked to the second PDR.

N40 interface:

- First UUC is derived from the usage report of the first offline URR and has a service identifier.
- Second UUC is derived from the usage report of the second offline URR and has a service identifier.
- Third UUC is derived from the usage report of the URR_Online and does not have a service identifier.

**Note**

- Session-level URR is not associated to the configured URRs.
- If URR is configured, URR rulebase is derived from egcdr and is linked to both the first and second offline URRs along with URR_Online.

## Limitations

This feature has the following limitations:

- Tight interworking mode is not supported for the service which is at the rating group level.
- One service at the rating group level and another service at service ID level are not supported.

## Standards Compliance

The Different Reporting Level Support for Online and Offline Charging feature complies with the following standards:

- 3GPP TS 32.255
- 3GPP TS 32.290

# Failure Handling Scenarios

This section describes the different failure handling scenarios associated with the errors that occur during SMF charging.

# Application Error and Result Code Handling

SMF supports the application error codes from CHF at command level as defined in 3GPP TS 32.291 specification, version 15.3.0, section 6.1.7.3. The SMF also supports RG-level result codes as defined in 3GPP 32.291 specification, version 15.3.0 section 6.1.6.3.14.

The following labels are defined in the "chf_appl_err_stats" counter to indicate the CHF response failures at the application level.

- http2_err_code—Includes the following values:
  - 403
  - 400
  - 404
- appl_err_code—Includes the following values:
  - END_USER_REQUEST_REJECTED
  - END_USER_SERVICE_DENIED
  - QUOTA_LIMIT_REACHED
  - CHARGING_NOT_APPLICABLE
- appl_err_action—Includes the following values:
  - drop_traffic
  - disable_charging
  - terminate
- appl_err_exchg_type—Includes the following values:
  - initial
  - update

## N40 Application Error Codes

The following table provides details of the application error codes with the corresponding SMF action.

| Application Error /Session Level | HTTP2 Code | SMF Action | CHF Expected Actions | Limitations |
|---|---|---|---|---|
| CHARGING_FAILED | 400 | Terminate | None | None |
| RE_AUTHORIZATION_FAILED | 400 | None | Take corrective action | - |
| CHARGING_NOT_APPLICABLE | 403 | Continue subscriber session without Charging (no offline charging as well) | None | None |

| Application Error /Session Level | HTTP2 Code | SMF Action | CHF Expected Actions | Limitations |
|---|---|---|---|---|
| USER_UNKNOWN | 404 | Terminate | None | None |
| END_USER REQUEST_DENIED | 403 | Terminate | None | None |
| QUOTA_LIMIT_REACHED | 403 | Drop traffic for the online services. Offline services are not impacted. | CHF sends notify (RAR) after this condition is recovered for the session | |

**Note**

- The error code 403 is not configured in the failure handling template.
- CHARGING_NOT_APPLICABLE (Disable charging) for static and predefined rules, occurs when a proprietary IE “Charging Disabled” in subscriber params is sent in the N4 modification or establishment request. This request is sent to prevent UPF from generating Start of Traffic for the URRs pending for activation. This IE is no longer sent in 2023.01.0 release and beyond. For more information, see the Handling Charging Disable Functionality section.

# Gy Application Error Codes

Gy supports application-level error codes in MSCC-level and Command-level supported by SMF from the OCS server.

## MSCC-level Failures

The following tables list the MSCC-level failure codes:

***Table 9: Transient Failures (4xxx)***

| Result Code | Description |
|---|---|
| 4010 | DIAMETER_END_USER_SERVICE_DENIED |
| 4011 | DIAMETER_CREDIT_CONTROL_NOT_APPLICABLE |
| 4012 | DIAMETER_CREDIT_LIMIT_REACHED |

***Table 10: Permanent Failures (5xxx)***

| Result Code | Description |
|---|---|
| 5003 | DIAMETER_AUTHORIZATION_REJECTED |
| 5012 | DIAMETER_UNABLE_TO_COMPLY |
| 5030 | DIAMETER_USER_UNKNOWN |
| 5031 | DIAMETER_RATING_FAILED |

*Table 11: Error Codes*

| ResultCode | Behaviour |
|---|---|
| 4010/4012(CCAI) | • CCAI is received withc4010/4012.<br>• PFCP_SESSION_ESTABLISHMENT_REQUEST is sent with CREATE FAR with APPLY ACTION as DROP:1, CREATE URR is sent with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 0, 'up_vol': 0, 'down_vol': 0}, TIME_QUOTA as 'tm_quta' : 0 |
| 4010/4012(CCAU) | • CCAI is received withc4010/4012.<br>• PFCP_SESSION_MODIFICATION_REQUEST is sent with UPDATE FAR with APPLY ACTION as DROP:1,UPDATE URR is sent with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 0, 'up_vol': 0, 'down_vol': 0}, TIME_QUOTA as 'tm_quta' : 0. |
| 4010/4012(CCRT) | • PFCP_SESSION_DELETION_REQUEST is received with usage report with "timqu" trigger.<br>• CCRT is sent with 3GPP-Reporting-Reason as “FINAL” |
| 4011(CCAI) | • CCAI is received with 4011.<br>• PFCP_SESSION_ESTABLISHMENT_REQUEST is sent with CREATE FAR APPLY ACTION as DROP:1, CREATE URR with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 9223372036854775807, 'up_vol': 9223372036854775807, 'down_vol': 9223372036854775807}, TIME_QUOTA as 'tm_quta' : 2147483647, TIME_THRESHOLD as 'time_treshold' : 10. |

| ResultCode | Behaviour |
|---|---|
| 4011(CCAU) | • CCAI is received with 4011.<br>• PFCP_SESSION_MODIFICATION_REQUEST is sent with UPDATE FAR APPLY ACTION as DROP:1, UPDATE URR with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 9223372036854775807, 'up_vol': 9223372036854775807, 'down_vol': 9223372036854775807}, TIME_QUOTA as 'tm_quta' : 2147483647, TIME_THRESHOLD as 'time_treshold' : 10. |
| 4011(CCRT) | • PFCP_SESSION_DELETION_REQUEST received with usage report with "timqu" trigger.<br>• CCRT is sent without MSCC. |
| 5003/5012/5030/5031<br>(CCAI) | • CCAI is received with 5003/5012/5030/5031.<br>• PFCP_SESSION_ESTABLISHMENT_REQUEST is ent with CREATE FAR with APPLY ACTION as DROP:1, CREATE URR with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 0, 'up_vol': 0, 'down_vol': 0}, TIME_QUOTA as 'tm_quta' : 0 |
| 5003/5012/5030/5031<br>(CCAU) | • CCAU is received with 5003/5012/5030/5031.<br>• PFCP_SESSION_MODIFICATION_REQUEST is sent with UPDATE FAR with APPLY ACTION as DROP:1, UPDATE URR with REPORTING_TRIGGERS as "volqu, timqu" and VOLUME_QUOTA as 'volume_quota' : {'dlvol': 1, 'ulvol': 1, 'tovol': 1, 'total_vol': 0, 'up_vol': 0, 'down_vol': 0}, TIME_QUOTA as 'tm_quta' : 0. |
| 5003/5012/5030/5031<br>(CCRT) | • PFCP_SESSION_DELETION_REQUEST is received with usage report with "timqu" trigger.<br>• CCRT is sent with USU (time(0)+volume(0)) and 3GPP-Reporting-Reason as "FINAL" |

### Command-level Failures

The Diameter endpoint pod handles the failure handling configuration after receiving a command-level failure for a Gy message from OCS.

Following are the actions and subactions applicable for Gy:

- Continue
  - FHSubActionEnum_UNKNOWN
  - FHSubActionEnum_DISCARD_TRAFFIC
- Terminate
  - FHSubActionEnum_WITH_TERM_REQUEST
  - FHSubActionEnum_WITHOUT_TERM_REQUEST

You can configure a failure handling profile with the preceding actions and subactions for following failure types that are received in CCA-I, CCA-U, or CCA-T messages:

- Any
- Result-code



**Note** The value ranges from 3000 to 9999.

- Exp-result-code



**Note** The value ranges from 3000 to 9999.

- Local-error

## RG-level Result Codes

The following table provides details of the result code with the corresponding SMF action.

| RG-level Result code | HTTP Status Code | SMF Behaviour | CHF Expected Behaviour | Limitations |
|---|---|---|---|---|
| RATING_FAILED | 200 | Drop traffic corresponding to the rating group | None | None |
| QUOTA_MANAGEMENT_NOT_APPLICABLE | 200 | Convert to offline | None | None |
| USER_UNKNOWN | 200 | Ignored (supported only at session level) | Not expected from CHF | None |

| RG-level Result code | HTTP Status Code | SMF Behaviour | CHF Expected Behaviour | Limitations |
|---|---|---|---|---|
| END_USER SERVICE_DENIED | 200 | Drop traffic corresponding to the rating group | CHF sends notify (RAR) after this condition is recovered for the rating group. | Traffic will be dropped for offline service as well for online or offline services. |
| QUOTA_LIMIT_REACHED | 200 | Drop traffic corresponding to the rating group | CHF sends notify (RAR) after this condition is recovered for the session | None |
| END_USER SERVICE_REJECTED | 200 | Drop traffic corresponding to the rating group | CHF sends notify (RAR) after this condition is recovered for the session | None |

## Handling Charging Disable Functionality

The SMF performs the following functions when the charging transactions are disabled on N40 interface:

- Deletes the already created Usage Reporting Rules (URR) on N4.
- Sends the proprietary IE "Charging Disabled" in subscriber params attribute through the N4 establishment or modification request.

This Custom N4 IE has some functional impact on other kinds of Charging like Radius-Accounting etc.

To eliminate the identified challenges at UPF, the SMF undergoes the following behavior changes when disabling the charging process:

- For newly loaded rules, SMF doesn't construct new dynamic URR.
- SMF stops sending the Charging Disabled IE to the UPF. The UPF continues to send the Usage Report (USAR) to the SMF for the other URRs.
- The SMF then acknowledges UPF with a successful response message. If the report demands usage quota, SMF relays infinite quota without requesting for the N40 usage details through N4 modification response.

## Charging Server Reconciliation

The SMF falls back to the first available offline CHF server when the NF selected by NF discovery is unreachable. The CHF Reconciliation feature involves deleting the existing subscribers that are associated to a set of offline NFs, and the subscribers that are in offline fallback mode.



**Note** The CHF reconciliation is applicable only when CHF endpoint is selected by NRF through NF discovery service.

The CHF server reconciliation works when one of the following two conditions is met:

1. If the NRF detects that an offline CHF server is active.
2. If the RAR is received from the CHF server on an offline converted session.

For the second condition, the session gets deleted directly. With the NF discovery, this feature involves the following steps:

1. SMF subscribes for the notification of NF instance IDs from NRF through NF_LIB component of Rest-EP.
2. If the NF discovery query determines that all the NFs are down, the NF_LIB component treats these set of NFs as offline. If any one of the NFs is available again, the NRF triggers notification for the same to the SMF.
3. The SMF performs NF discovery after revalidation timer. If the NRF detects any new NF, the SMF receives the corresponding notification from the NRF.
4. When the SMF identifies that an NF is online with all the required NF discovery query parameters, then the SMF initiates the CHF server reconciliation.

The following labels are introduced as part of this feature:

- disc_pdurel_chf_reconciliation: This label is defined under SMF_DISCONNECT_STATS to show the reason of disconnection.
- chf_reconl_pdu_sess_rel: This label is defined under smf_service_stats metric to show the number of times the PDU session release procedure is initiated.

# Dynamic Update of Charging Configurations

## Feature Description

The Dynamic Configuration Change Support feature allows SMF to dynamically handle the configuration changes of the charging parameters while minimizing the configuration errors. The existing and new SMF Charging parameters allow implementation of the dynamic configuration updates. This feature supports the following charging configurations:

- Active Charging Service (ACS) Profile
    - Rulebase

  - Ruledef
  - Charging-Action
  - Credit-Control-group
- Charging Profile
- Charging Characteristics
- GTPP Group
- Upf-Apn Configuration Group

# How it Works

This section describes how dynamic change in configuration works for the supported Failure Handling Profile and Charging Profile configuration.

## ACS Profile

The SMF supports dynamic change in the ACS configuration during the run time. The ACS Profile configuration defines various parameters for the ACS profile.

The following table lists the SMF and UPF behavioral changes during the dynamic update of ACS configuration in different scenarios.

***Table 12: ACS Profile Configurations and its Impact during Dynamic Update***

| Configuration | Config Applied on both SMF and UPF | Config Applied only on SMF | Config Applied only on UPF |
|---|---|---|---|
| Rulebase addition | **Existing Session**: Continue to use the current rulebase value<br>**New Session**: No impact for the new session | **Existing Session**: Change in the rulebase gets rejected at UPF<br>**New Session**: Session creation fails at UPF for this rulebase | **Existing Session**: Change in the rulebase gets rejected at SMF<br>**New Session**: Session creation fails at SMF for this rulebase |
| Rulebase removal | **Existing Session**: Not allowed without node drain<br>**New Session**: No impact for the new session | **Existing Session**: Not allowed without node drain<br>After the configuration change, the rulebase configuration remains stale on SMF if the rulebase removal on UPF is missed<br>**New Session**: No impact for the new session | **Existing Session**: Not allowed without node drain<br>After the configuration change, the rulebase configuration remains stale on UPF if the rulebase removal on SMF is missed<br>**New Session**: No impact for the new session |

| | | | |
|---|---|---|---|
| Ruledef addition | **Existing Session**: Activates the new rule successfully<br>**New Session**: No impact for the new session | **Existing Session - Static Rule**: The UPF neither activates the rule nor sends the report for this rule.<br>**Existing Session - Predefined Rule**: Fails to activate the new rule until the UPF receives it.<br>**New Session**: Same as the existing session | **Existing Session - Static Rule**: The UPF activates this rule and reports the usage. The SMF has the charging data for this RG+ServID. It creates dummy ChargParam and associates URR to it.<br>**Existing Session - Predefined Rule**: Fails to activate the new rule until the SMF receives it<br>**New Session**: Same as the existing session |
| Ruledef deletion | **Existing Session**: The current flows remain as is. If the flow is not created, it will never be created for this session. The SMF or UPF does not remove the associated charging.<br>**New Session**: No impact for the new session | **Existing Session - Predefined rule** : The SMF rejects this rule creation.<br>**Static and Activated Predefined Rules:** Existing flows remain as is. The SMF or UPF does not remove the associated charging. The received usage is reported successfully.<br>If the SMF has not received the first usage report and when the first report arrives, the SMF creates chargParam/Urr context from RG+ServID.<br>**New Session**: Same as the existing session | **Existing Session - Predefined rule**: The SMF continues to allow this rule creation but fails at the UPF.<br>**Static and Activated Predefined Rules**: The UPF continues with the created URR for these flows. The SMF reports the usage without any issue.<br>**New Session**: Same as the existing session |
| Charging Action addition with new RG/Svc Id (With addition of new rules associated to that CA) | **Existing Session - Static Rule**: The SMF creates charging entry for this RG when the first URR is received.<br>**Existing Session - Predefined Rule**: The SMF activates the rule based on the PCF trigger.<br>**New Session**: No impact for the new session | **Existing Session - Static Rule**: The UPF does not activate this flow. The SMF never receives the usage.<br>**Existing Session - Predefined Rule**: The UPF fails to install predefined rule due to the unavailability of ruledef info.<br>**New Session**: Same as the existing session | **Existing Session - Static Rule**: The UPF activates this flow. The SMF creates the charging entry for this RG when the first URR is received.<br>In this case, the SMF does not find Charging-action with this RG+ServID. It creates dummy ChargParam with the received RG+ServID.<br>**Existing Session - Predefined Rule**: Same as mentioned for the static rule.<br>**New Session**: Same as the existing session |

| | | | |
|---|---|---|---|
| Charging action (and associated rules) removal | **Existing Session - Static Rules**: The SMF and UPF continue with the current flow and report any URRs for this RG.<br>**Predefined Rules**:<br>The SMF and UPF continue with the current flow and report any URRs for this RG. Once the rule is deactivated, it will not be activated again.<br>**New Session**: No impact for the new session | **Existing Session - Static Rules**: The SMF and UPF continue with the current flow and report any URRs for this RG.<br>**Predefined Rules**:<br>The SMF and UPF continue with the current flow and report any URRs for this RG. Once the rule is deactivated, it will not be activated again.<br>**New Session**: Same as the existing session | **Existing Session - Static Rules**: The SMF and UPF continue with the current flow and report any URRs for this RG.<br>**Predefined Rules**:<br>The SMF and UPF continue with the current flow and report any URRs for this RG. Once the rule is deactivated, it will not be activated again.<br>**New Session**: Same as the existing session |
| RG/Svc Id, Online/Offline Config changed within CA | **Static Rules and Already Active Predefined Rules**: The UPF creates new URRs and reports them. The SMF reconciles from URR ID table and creates charging data for these URRs as and when reported.<br>**Post config change activation of predefined rules**: No issues. Both SMF and UPF are in sync.<br>**New Session**: No impact for the new session | **Static Rules and Already Active Predefined Rules**: The UPF continues reporting with old URR ID and the SMF continues to report it without any issue.<br>**Post config change activation of predefined rules**: Same as Static Rules<br>**New Session**: The UPF rejects the establishment request if the predefined rules are activated during session establishment. | **Static Rules and Already Active Predefined Rules**: The UPF creates new URRs and reports them. The SMF reconciles from URR ID table and creates dummy chargParam and associates URR to it.<br>**Post config change activation of predefined rules**: Same as Static Rules<br>**New Session**: The UPF rejects the establishment request if the predefined rules are activated during session establishment. |
| URR Id table entry addition<br>(New RG addition) | No action needed on SMF | No action needed on SMF | The UPF creates URR. |
| URR Id table entry removal | No impact | No impact | The UPF creates URR. The removal has no impact on the created URR. |

| | | | |
|---|---|---|---|
| URR Id table entry modification | No impact | No impact | The UPF creates URR. Removal has no impact on the created URR.<br>If the same URR-id is allocated to different RG+ServID, the removal impacts the URR. The UPF fails to create new URR for the new RG+ServId. |

**NOTES:**

- If the online report includes service id and the ignore-service-id is not configured in credit control profile, the SMF drops the report.
- If the new online URR contains the same RG as an existing URR, then the SMF drops the usage report.
- If the new offline URR contains the same RG+service ID as an existing URR, the SMF drops the usage report.
- In the same usage report, if the next online URRs include the same RG and the next offline URRs include with the same RG + service ID, the SMF drops the usage report.

## Charging Profile

The Charging Profile supports dynamically updating the configuration based on the values that you pass during the runtime. The refresh operation of the values takes place considering the following scenarios:

- **Configuration reflects in the next encounter to access:** If the values are updated while an operation is in-progress, the SMF ignores the new values and continues to use the old values. For example, Limits in Charg-Profile and CC triggers.
- **Configuration reflects only on a new session:** If the configuration is specific to a session and the session has already considered the values, then the SMF does not consider the new values. For example, PduContext (DB entry). This case indicates that any update to the configuration does not impact the sessions that are already created. For instance, Charging Method in Profile or Charg-Profile in Charging Characteristics.
- **Configuration reflects instantly:** Configurations immediately consider the dynamic values whenever they are updated. If SMF has already used a configuration and it is later updated, then it uses the latest values.

If a session is created using a Charging Profile, which later gets deleted from the Ops Center, the session might attempt to access the configuration structure of the deleted profile. In such cases, the Smf-Service pod maintains a default profile mapped to the sessions whose profiles are missing.

The Charging Profile is responsible for handling the SMF charging parameters.

The following table lists the configuration parameters with the dynamic configuration change and its impact on the existing sessions.

*Table 13: Charging Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| limit rating-group duration | Allowed | New values are used during the new URR creation or the subsequent URR update for the existing sessions<br>**Note** The dynamic configuration does not initiate a URR update. |
| max-charging-condition | Allowed | No impact |
| max-deferred-urr | Allowed | No impact |
| metering-method | Allowed | New values are used during the new URR creation for the existing sessions |
| method | Allowed | No impact |
| reporting-level | Allowed | No impact |
| requested-service-unit time | Allowed | No impact |
| tight-interworking-mode | Allowed | No impact |
| triggers session | Allowed | No impact |
| Request Quota | Allowed | No impact |
| session-failover | Allowed | No impact |
| dynamic-rules | Allowed | No impact |
| send charging-initial | Allowed | No impact |
| quota Validity-Time | Allowed | No impact |
| quota volume-threshold | Allowed | No impact |
| usage-reporting | Allowed | No impact |
| mscc-final-unit-action | Allowed | No impact |
| max-secondary-rat-reports | Allowed | Impact |
| egcdr losdv-max-containers | Allowed | Impact |
| egcdr service-data-flow | Allowed | No impact |
| egcdr closure-reason | Allowed | Impact |
| egcdr triggers | Allowed | Impact |
| egcdr suppress-cdrs zero-volume | Allowed | Impact |

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| egcdr-final-record | Allowed | Impact |

## Charging-Characteristics Profile

The Charging-Characteristics Profile configuration defines the various parameters for managing the charging characteristics for SMF Charging.

The following table illustrates if the configuration parameters allow dynamic configuration change.

*Table 14: Charging-Characteristics Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| charging-profile | Not Allowed | The configuration is used only once while setting up the session. |

## Charging-Action Profile

The Charging-Action Profile configuration defines the QoS and charging related parameters associated with the rule definitions.

The following table illustrates if configuration parameters allow dynamic configuration change.

*Table 15: Charging-Action Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Rating group and Service ID | Allowed | No impact |

## Credit-Control-Group Profile

The Credit-Control-Group configuration defines the parameters to be used for subscribers who use the mapped rulebase.

The following table illustrates if configuration parameters allow dynamic configuration change.

*Table 16: Credit-Control-Group Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Ignore Service ID | Allowed | No impact |

## Rulebase Profile

The Rulebase configuration parameters define the protocol rules to match a flow and the associated actions to be taken for the matching flow.

The following table illustrates if configuration parameters allow dynamic configuration change.

*Table 17: Rulebase Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Ruledef association to Charging-action | Allowed | No impact |
| Credit-Control-Group | Allowed | The configuration is used only once while setting up the session |

## GTPP Group Profile

The GTPP Group Profile configuration specifies the parameters for creating the GTPP group.

The following table illustrates if configuration parameters allow dynamic configuration change.

*Table 18: GTPP Group Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Limits for offline configured urrs | Allowed | New values are used during the new URR creation for the existing sessions. |

## UPF-APN Configuration Profile

The UPF-APN Configuration Profile configuration defines the various parameters for the UPF-APN profile.

The following table illustrates if the configuration parameters allow dynamic configuration change.

*Table 19: UPF-APN Configuration Profile Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Association of GTPP Group | Allowed | The configuration is used only once while setting up the session. |

## Network Profile for Peer CHF

The network profile for peer CHF configuration defines the various network configurations.

The following table illustrates if configuration parameters allow dynamic configuration change.

*Table 20: Network Profile for Peer CHF Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Set of CHFs configured | Allowed | No impact |

## Network Profile for Peer OCS

The network profile for peer OCS configuration is to enable Gy interface.

The following table illustrates whether the configuration parameters allow dynamic configuration change.

*Table 21: Network Profile for Peer OCS Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Set of OCS servers configured | Allowed | No impact |

### Network Profile for Peer OFCS

The network profile for peer OFCS configuration is to enable the Gz interface.

The following table illustrates whether the configuration parameters allow dynamic configuration change.

*Table 22: Network Profile for Peer OFCS Parameters*

| Configuration Parameters | Dynamic Change | Impact on Existing Sessions |
|---|---|---|
| Set of OFCS servers configured | Allowed | No impact |

# Usage reporting on rulebase change

This support introduces a call flow dictionary configuration that allows SMF to conditionally skip the N40 interface and defer CHF interaction during handovers (intra- and inter-PLMN) if a PCF interaction is required. In such cases, UPF usage data is stored locally and pushed to CHF only after the PCF interaction is completed. If no PCF interaction is needed, N40 processing continues normally.

Additionally, upon receiving an N7 response, a dedicated bearer procedure with higher priority is initiated, which can be aborted by other high-priority procedures (except while awaiting an N4 response). A new configuration is introduced under the charging profile (report-trigger management-intervention condition rb-change) that enables SMF to query and report usage to CHF upon an RB (Rulebase) change. This enhances usage reporting while preserving existing PDR handling and UPF URR association behaviors, and maintaining the current N7 update sequence.

This feature introduces more dynamic and flexible handling of usage reporting and rulebase changes, particularly during handovers and when interacting with the Charging Function (CHF) and Policy Control Function (PCF) with following actions.

- **Usage reporting on rulebase (RB) changes**: When an RB change is detected and the corresponding configuration is enabled, the SMF will query the usage for all affected rules and report this information to the CHF. SMF will use management intervention as the trigger for reporting the usage to CHF.
- **PDR and URR handling**: The behavior of deleting Packet Detection Rules (PDRs) for old rules and creating new PDRs for new rules remains unchanged. The UPF continues to associate existing Usage Reporting Rules (URRs) with new PDRs if the old and new rules are associated with the same Rule Group (RG) or Service ID. If new rules are linked to a different RG/Service ID, the UPF will create new URRs.
- **N7 update and CHF interaction**: The SMF maintains its current practice of performing N7 updates as the final step during handovers. If appropriate triggers are enabled, the CHF update will occur after the N7 update.

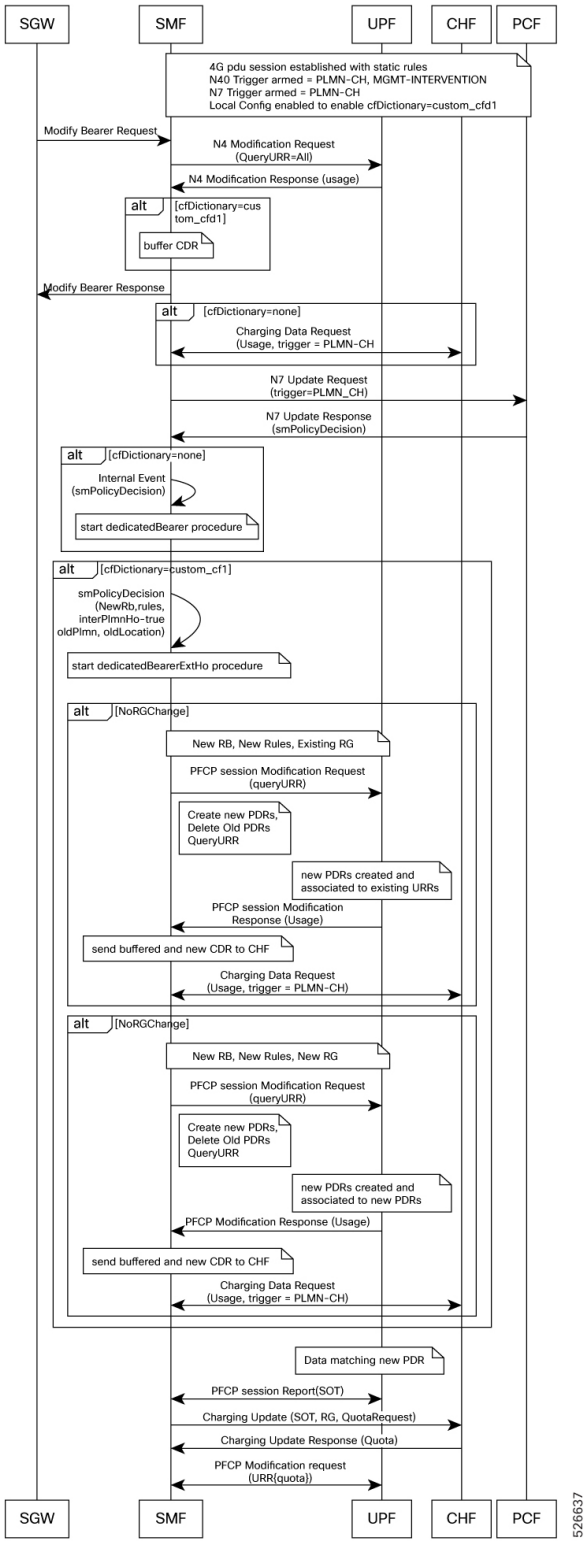
### Inter-PLMN 4G handover - dynamic charging updates on rulebase change

The following call flow illustrates how, during an inter-PLMN 4G to 5G handover, SMF immediately queries and reports usage to CHF upon rulebase change, with behavior governed by the call-flow dictionary configuration, and details both standard and enhanced charging interactions involving rule group changes, URR handling, and quota updates.



**Note** Similar call flows and handling apply to inter-PLMN N2 handover, inter-PLMN 5G to 4G handover, and inter-PLMN 4G to 4G handover scenarios.

***Figure 5: Inter PLMN 4G handover***



### Enhanced handover resilience and deferred CDR reporting

If an N7 response fails or times out, the system will initiate a high-priority dedicated bearer procedure to extend the handover process. This procedure can be interrupted by another higher-priority process while awaiting a CHF response, but not while waiting for an N4 response. With this feature enabled, CHF update will happen after the N7 update. Separately, if an N4 failure occurs during a Rulebase change, the SMF will delay sending old CDRs until the next interaction with the CHF. Wifi handovers behavior remains unchanged with the new dictionary.

## Configure delayed CHF functionality

Follow these steps to enable the delayed CHF functionality:

### Procedure

**Step 1** Create an instance of the network element profile.

**Example:**

```
config
  profile network-element chf chf_name
```

**Step 2** Configure the name of the charging function dictionary..

**Example:**

```
config
  profile network-element chf chf_name
  cf-dictionary cf_dict_name
  end
```

**Step 3** Create a charging profile instance.

**Example:**

```
  profile charging prof_name
```

**Step 4** Enable SMF to query and report usage to CHF upon an rulebase change.

**Example:**

```
  profile charging prof_name
  report-trigger [management-intervention] condition [rb-change]
  end
```

# Fetch Preemptive Quota with Static and Predefined Rules

*Table 23: Feature History*

| Feature Name | Release Information | Description |
|---|---|---|
| Preemptive Quota Requests for Static and Predefined Rules | 2024.02.0 | In SMF, Preemptive Quota is enabled by default for Dynamic rules.<br>Through this feature enhancement, SMF can request Preemptive Quota for static and predefined rules during the initial attach session creation process.<br>The preemptive quota is configurable using the **preemptively-request-n-validate** command in the **Charging Action Configuration** mode.<br>**Default Setting**: Enabled – Always-on |

## Feature Description

SMF uses the Online Charging System (OCS) /Gy interfaces to generate charging events. The OCS acts as the Diameter Credit Control server, which provides the online Charging data to the SMF. With the Gy interface, customer traffic gets gated and billed in an online or prepaid manner. SMF supports both the time-based and volume-based charging models.

In SMF, Quota management is allowed per Rating Group (RG) for each PDU session. For static and predefined rules, earlier, SMF requested Quota fetch from the Charging Function (CHF) only when the data packet started flowing and the “START OF TRAFFIC” notification is sent from the UPF to the SMF.

Now, SMF can request Preemptive Quota for static and predefined rules during the initial attach session creation process through a **preemptively-request-n-validate** CLI configuration. The Preemptive Quota requests gets attached and sent during N11, N16, S5, S8, or S2b creation procedures. The PDU setup or attach is rejected if any error is received from the CHF for quota-request.

During rejection, SMF sends appropriate notifications in the following scenarios.

- If no quota is received, SMF rejects the session create with cause “no resources”.
- If the session create is through NR RAT for homers, SMF sends N11 N1N2 transfer message with N1 PDU Establishment Reject with cause “Insufficient resources” followed by N11 status notification with cause =” REL_DUE_TO_UNSPECIFIED_REASON”.
- If the session create is through NR RAT for roamers, SMF sends N16 PduSessionCreateError with N1 cause = “Insufficient resources”.
- If the session create is through EUTRA/WIFI, SMF sends a create session response with cause "No resources available”.

Any runtime change or addition of any predefined rule or rulebase for an active session does not result in Preemptive Quota. Quota request is sent only on receiving start-of-traffic from the UPF.

# How It Works

The Preemptive Quota is used only for validation of the attach procedure or PDU setup. When a charging action is configured with **cca charging credit preemptively-request-n-validate traffic-start-trigger** *trigger_type_name* the SMF sends the Quota request to the CHF for a selected rating group. Based on the quota received, SMF accepts or rejects the PDU session. If there is any quota-related error or no quota that is received during PDU session creation, SMF rejects the session creation with cause as "no resources".

SMF does not store the volume quota. On receiving the start of traffic message from the UPF, SMF again goes to CHF to get the quota. SMF indicates the current usage as 0 for the CHF to resend the quota again.

SMF starts the timer if a time quota or time threshold or holding time is received.

One of the following functions can occur:

- If “start of traffic” is received before timer expiry, SMF stops the timer and sends the quota request to the CHF along with usage=0 and trigger=configured or default trigger MANAGEMENT_INTERVENTION.
- If the timer expires before “start of traffic”, then SMF sends a usage report to the CHF with usage=0 and trigger=TIME_LIMIT and quota request and handles it the same way as the quota that is received during session create.

During attach or PDU setup, when the CHF initial request is sent asking for quota, the START_OF_SERVICE_DATA_FLOW trigger will be used."

## Call Flows

This section describes the call flow associated with the Pre-emptive Quota Request for the 5G sessions.

*Figure 6: Preemptive Quota Request Call Flow -Start of Traffic Before Timer Expiry*

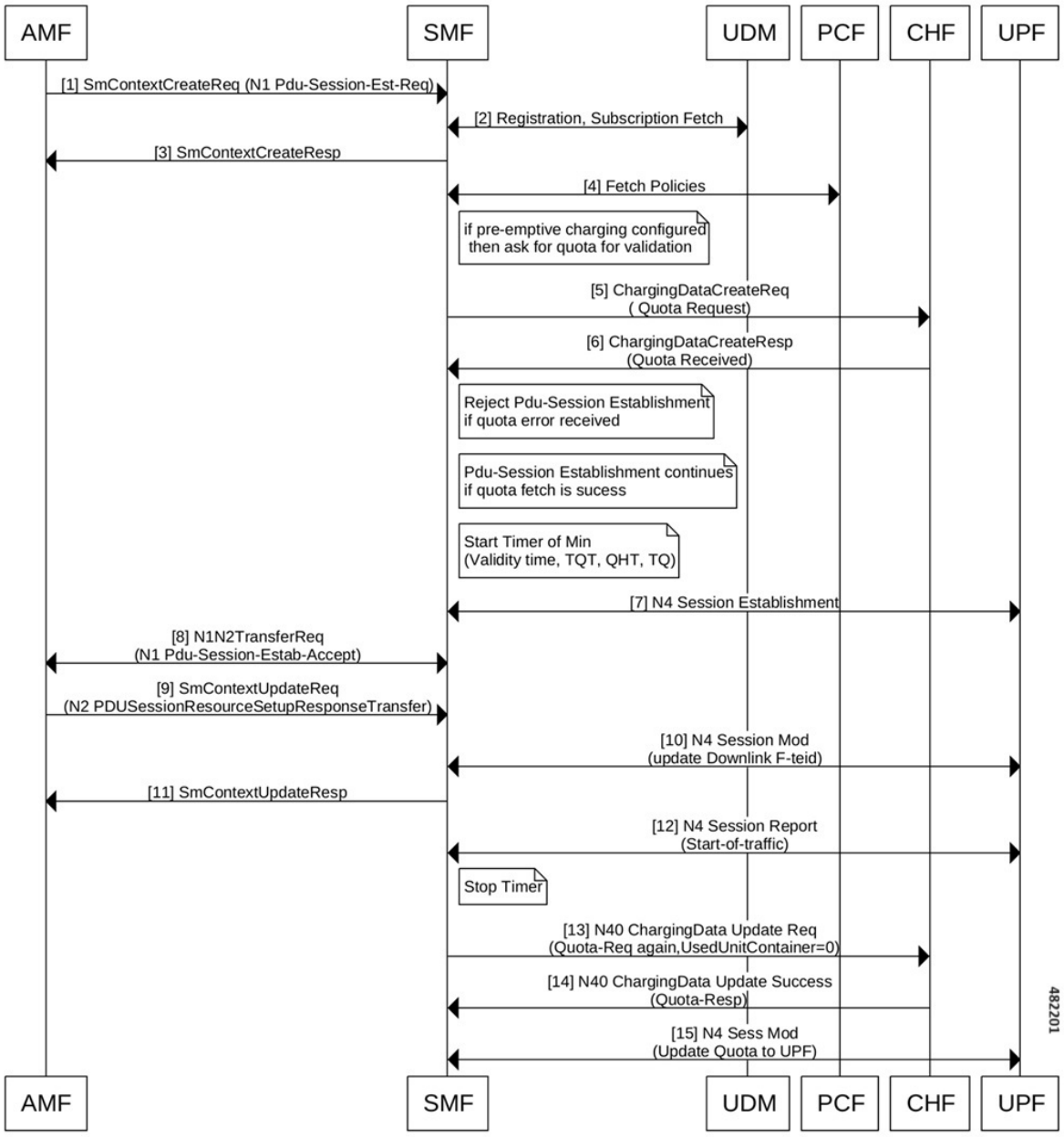



*Table 24: Preemptive Quota Request Call Flow Description*

| Step | Description |
|---|---|
| 1 | AMF sends N1 PDU session create request to the SMF. |
| 2 | SMF sends the Subscription Fetch Request to the UDM. Then, UDM sends the Subscription Fetch Response to the SMF. |
| 3 | SMF sends Context create response to the AMF. |

| Step | Description |
|---|---|
| 4 | SMF negotiates the fetch policies with the PCF.<br>**Note**<br>If preemptive charging is configured then SMF requests for quota validation. |
| 5 | If preemptive charging is configured, SMF requests quota in the Charging Data Create Request for the rating groups configured, and also for the predefined rules received during PCF interaction. |
| 6 | The CHF responds back to the SMF with Quota.<br>**Note**<br>One of the following fuction can occur:<br>• If the Quota error is received, SMF rejects the PDU session establishment<br>• If the Quota fetch is success, SMF continues with the PDU session establishment.<br><br>Timer gets started with value Min {ValidityTime,TQT,QHT,TQ}. Any start of traffic received after this results in quota request to CHF.<br>**Note**<br>The value of timer started would be minimum of this values<br>• ValidityTime (VT)<br>• QuotaHoldingTime (QHT)<br>• TimeQuotaThreshold subtracted from TimeQuota (TQ-TQT) |
| 7 | SMF initiates N4 session establishment request exchange with UPF. In the same request, SMF relays the information related to charging in the Create URRs.. |
| 8 | SMF sends the N1N2 exchange and SM Context Update Exchange to AMF. |
| 9 | AMF sends SMContext update request to the SMF to communicate about the PDU session resource setup. |
| 10 | SMF performs N4 Session Modification to update downlink FTEIDs. |
| 11 | SMF sends the SMContext Response to the AMF. |
| 12 | UPF sends start of traffic message to the SMF through N4 session report. |
| Stops preemptive quota timer. If the timer (step 6) expires before “start of traffic”, then SMF sends usage report to CHF with usage=0, so that the CHF can resend the quota again. | |
| 13 | SMF sends N40 Charging Data request requesting quota and with usage 0. |
| 14 | CHF responds back to the SMF with N40 Charging Data update success response message. |
| 15 | SMF sends quota update to the UPF. |

## Preemptive Quota Request Call Flow -Start of Traffic After Timer Expiry

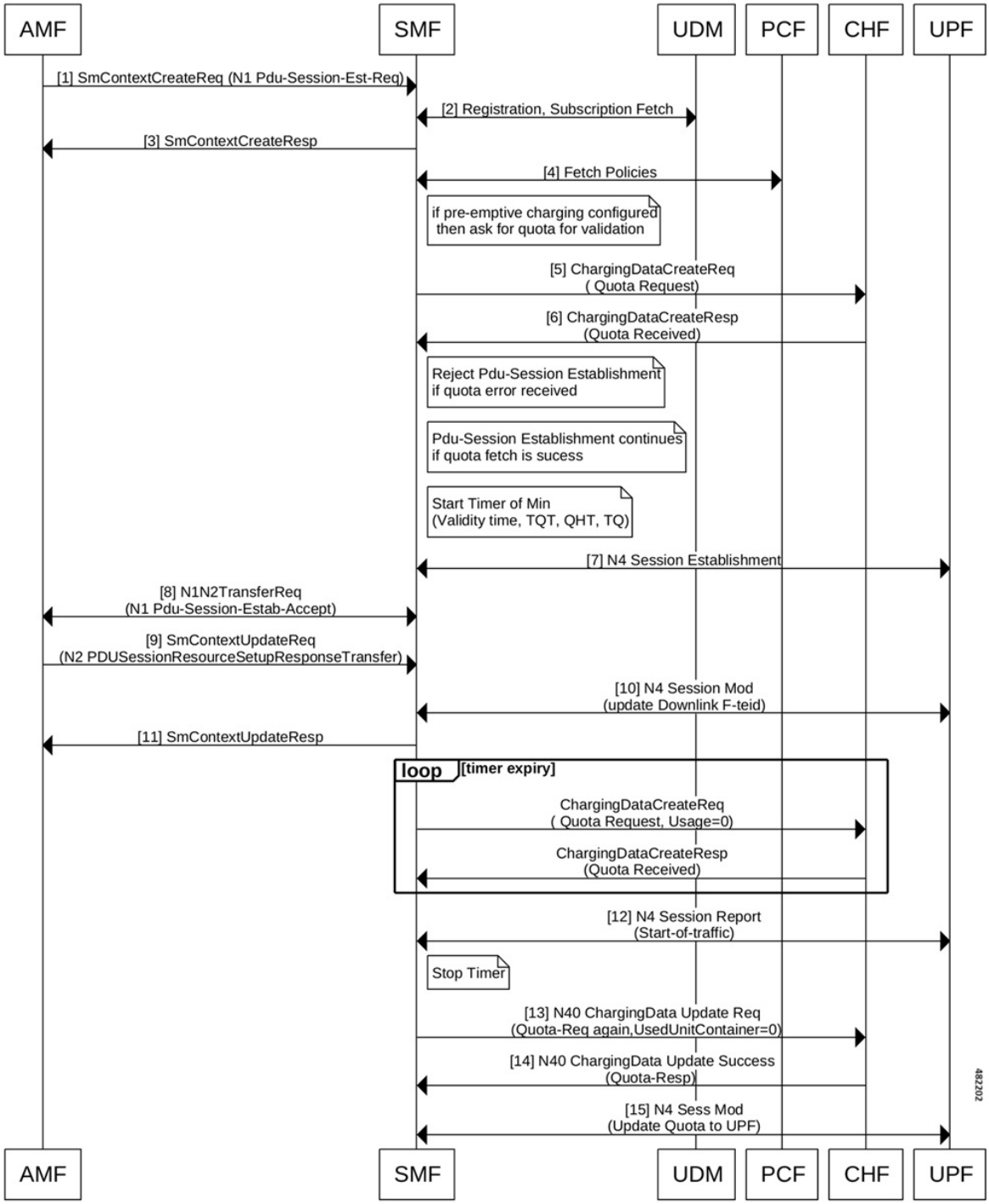


*Table 25: Preemptive Quota Request Call Flow Description*

| Step | Description |
|---|---|
| 1 | AMF sends N1 PDU session create request to the SMF. |
| 2 | SMF sends the Subscription Fetch Request to the UDM. Then, UDM sends the Subscription Fetch Response to the SMF. |
| 3 | SMF sends Context create response to the AMF. |
| 4 | SMF negotiates the fetch policies with the PCF. |
| 5 | If preemptive charging is configured, SMF requests quota in the Charging Data Create Request for the rating groups configured, and also for the predefined rules received during PCF interaction. |
| 6 | The CHF responds back to the SMF with Quota.<br>**Note**<br>One of the following fuction can occur:<br>• If the Quota error is received, SMF rejects the PDU session establishment<br>• If the Quota fetch is success, SMF continues with the PDU session establishment.<br><br>Timer gets started with value Min {ValidityTime, TQT, QHT,TQ}. Any start of traffic received after this results in quota request to CHF.<br>**Note**<br>The value of timer started would be minimum of this values<br>• ValidityTime (VT)<br>• QuotaHoldingTime (QHT)<br>• TimeQuotaThreshold subtracted from TimeQuota (TQ-TQT) |
| 7 | SMF initiates N4 session establishment request exchange with UPF. In the same request, SMF relays the information related to charging in the Create URRs.. |
| 8 | SMF sends the N1N2 exchange and SM Context Update Exchange to AMF. |
| 9 | AMF sends SMContext update request to the SMF to communicate about the PDU session resource setup. |
| 10 | SMF performs N4 Session Modification to update downlink FTEIDs. |
| 11 | SMF sends the SMContext Response to the AMF. |
| (loop) The pre-emptive quota timer started at step6 expires. SMF sends usage report to CHF with usage=0, so that the CHF can resend the quota again. | |
| 12 | UPF sends start of traffic message to the SMF through N4 session report. Stops pre-emptive quota timer |
| 13 | The SMF sends a Charging Data request requesting quota and with usage 0. |
| 14 | Then, the CHF responds back to the SMF with N40 Charging Data request Success response. |

| Step | Description |
|---|---|
| 15 | SMF sends the quota details to UPF. |

# Configuring Preemptive Quota Request

Use the following CLI commands to configure preemptive quota request.

```
config
   active-charging service service_name
      charging-action charging_action
         cca charging credit [ preemptively-request-n-validate
traffic-start-trigger ]  trigger_type_name
         end
```

**NOTES:**

- **charging-action** *charging_action_name*: Specify the name of a charging action. *charging_action_name* must be an alphanumeric string of 1–63 characters and can contain punctuation characters. Each charging action must have a unique name.
- If the named charging action does not exist, it is created, and the CLI mode changes to the ACS Charging Action Configuration Mode wherein the charging action can be configured.
- If the named charging action exists, the CLI mode changes to the ACS Charging Action Configuration Mode for that charging action.
- **cca charging credit**: Enable or disable Credit Control Application (CCA) and configure the RADIUS/Diameter prepaid charging behavior.
- **preemptively-request-n-validate traffic-start-trigger** *trigger_type_name* : Specifies quota is preemptively requested and used only for validation.

  If this **preemptively-request-n-validate** is enabled for a rating-group configuration, SMF sends a quota request to CHF for that rating-group, and the quota is used only for validation of attach or PDU setup.

  **traffic-start-trigger** *trigger_type_name* is used for sending configured trigger type in the ChfUpdate during the start-of-traffic report from UPF. If this configuration is not available, then management_intervention trigger type is used by default.

### Configuration Example

The following is an example.

```
charging-action caOnline
  cca charging credit preemptively-request-n-validate traffic-start-trigger other_quota_type
```

# OAM Support

## Bulk Statistics Support

The SMF maintains the following metrics as part of the Preemptive Quota.

- disc_pdusetup_chf_rg_error: Indicates that the disconnect reason is pegged for pduSession-reject due to preemptive quota validation error.
- disc_pdnsetup_chf_rg_error: Indicates that the disconnect reason is pegged for attach-reject due to preemptive quota validation error.