

APN Rate Control for CIoT Devices

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Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	• C-SGN • P-GW
Applicable Platform(s)	• UGP • VPC-DI • VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not applicable
Related Documentation	• *Command Line Interface Reference* • *P-GW Administration Guide* • *Statistics and Counters Reference* • *Ultra IoT C-SGN Administration Guide*

Revision History

Revision Details	Release
First introduced.	21.15

Feature Description

In usual scenarios, CIoT-enabled UE send data packets infrequently. However, in unusual scenarios, UE can send data packets frequently during a short period resulting in network congestion and affecting services. APN Rate Control is one of the 3GPP standards-compliant mechanisms for rate limiting when UEs send data packets.

APN Rate Control allows Home Public Land Mobile Network (HPLMN) operators to control the amount of user data sent in Downlink (DL) and Uplink (UL). This is done with help of policing the user data on a maximum number of user data packets per time-unit, and/or maximum number of user data octets per time-unit, for both DL and UL.

How it Works

APN Rate Control policing for DL is done in the P-GW or the SCEF, and the APN Rate Control policing for UL is done in the UE. The P-GW or SCEF can also do APN Rate Control UL policing. For more information on:

- APN Rate Control UL in the UE, see 3GPP TS 24.301.
- APN Rate Control in the SCEF, see 3GPP TS 29.128.

Note The existing AMBR mechanisms are not suitable for APN Rate Control for CIoT Devices considering radio efficiency and UE battery-life. For example, an AMBR greater than 100 Kbps translates to a potentially large daily data volume.

The P-GW or Service Capability Exposure Function (SCEF) sends an APN Uplink Rate Control command to the UE using the PCO information element (IE). The APN Uplink Rate Control applies to data PDUs sent on that APN by either Data Radio Bearers (S1-U) or Signaling Radio Bearers (NAS Data PDUs). The UE complies with this uplink rate control instruction. The UE considers the rate control instruction as valid until it receives a new one from either P-GW or from SCEF. The P-GW or SCEF enforces the Uplink Rate Control by discarding or delaying packets that exceed the rate as indicated to the UE.

APN Rate Control Indications

APN Rate Control Indication Status is sent as part of Protocol Configuration Options (PCO)/Extended Protocol Configuration Options (ePCO). If P-GW/MME supports the ePCO as part of its capability exchange, the P-GW/S-GW sends the APN Rate Control parameters as part of ePCO. If ePCO is not supported by these entities, the P-GW/S-GW sends the APN Rate Control parameters as part of PCO.

As part of PCO/ePCO, the APN Rate Control parameters are sent as “additional parameters list”. A specific “container identifier” identifies the type of the parameter that is carried in a container. The “container identifier” related to the APN Rate Control are:

- Mobile Station (MS) to network direction:
  - 0016H (APN rate control support indicator)
  - 0019H (Additional APN rate control for exception data support indicator)
- Network to MS direction:
  - 0016H (APN rate control parameters)
  - 0019H (Additional APN rate control for exception data parameters)

When the “container identifier” indicates APN Rate Control support indicator, the “container identifier contents” field is empty and the “length of container identifier contents” indicates a length equal to zero. If the “container identifier contents” field is not empty, it is ignored. This information indicates that the MS supports APN Rate Control functionality.

When the “container identifier” indicates APN Rate Control parameters, the “container identifier contents” field contains parameters for APN Rate Control functionality.

When the “container identifier” indicates Additional APN Rate Control for exception data support indicator, the “container identifier contents” field is empty and the “length of container identifier contents” indicates a length equal to zero. If the “container identifier contents” field is not empty, it is ignored. This information indicates that the MS supports additional APN Rate Control for exception data functionality.

When the “container identifier” indicates Additional APN Rate Control for exception data parameters, the “container identifier contents” field contains parameters for additional APN Rate Control for exception data functionality.

APN Rate Control Status

APN Rate Control Status is the new IE, added as part of Create Session Request (CSReq), Delete Bearer Request (DBReq), and Delete Session Response (DSRes), which holds information of APN Rate Control Value. This IE is encoded as part of CSReq on the UR reattach to denote the P-GW about the remaining limits available for the subscriber on the current timeout period.

P-GW includes this IE when the DBReq is sent only for the default bearer, so that it can be used when the UE is attaching again. In addition, the P-GW includes this IE when the DSRes is sent to MME through S-GW.

	Bits								
Octets	8	7	6	5	4	3	2	1	
1	Type = 204 (decimal)								
2 to 3	Length = n								
4	Spare				Instance				
5 to 8	Number of Uplink packets allowed								
9 to 12	Number of additional exception reports								
13 to 16	Number of Downlink packets allowed								

17 to 24	APN Rate Control Status validity Time	
25 to (n+4)	These octet(s) is/are present only if explicitly specified	

Octets 17 to 24 are coded as time in seconds relative to 00:00:00 on 1 January 1900 (calculated as continuous time without leap seconds and traceable to a common time reference) where the binary encoding of the integer part is in the 32 most significant bits, and binary encoding of the fraction part in the 32 least significant bits. The fraction part is expressed with a granularity of 1/2**32 second.

The APN Rate Control Status information is sent by P-GW to MME through S-GW to store the APN Rate control parameters in Mobility Management (MM) context. This helps in restoring the rate control for the same subscriber when it is reestablished again after some time. The parameters are treated as the remaining messages on the remaining time period of the time-unit.

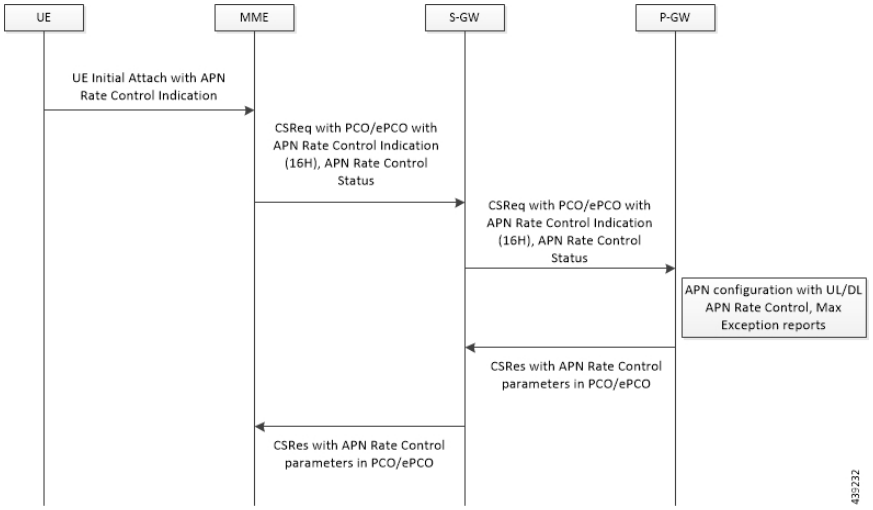
On reestablishment of the same subscriber (on first PDN for the same APN), the MME provides the information back to P-GW in PCO/ePCO. While processing, P-GW considers the values received from MME instead of its local configuration until the first timeout is complete.

Call Flows

This section describes the features' key call flows.

APN Rate Control Handling at P-GW on CSReq

On establishment or re-establishment of the subscriber for the APN, the MME sends the Indication Flags of APN Rate limit, Addition Exception indication, and APN Rate Control status in the CSReq.



Steps	Description
1	UE Initial Attach with APN Rate Control Indication is sent from UE to MME.
2	On receiving CSReq, the P-GW considers the APN Rate Control Status while encoding the APN Rate Control parameters in PCO, and while enforcing the APN Rate Control.
3	P-GW has two options to enforce the APN Rate Control:

Steps	Description
	1. On subsequent establishment of the first PDN connection for the given APN, the P-GW/SCEF receives the previously stored APN Rate Control Status, and if the first APN Rate Control validity period has not expired, it applies the received APN Rate Control Status and provides the related parameters to the UE in the PCO (instead of the configured APN Rate Control parameters). 2. If the initially applied parameters differ from the configured APN Rate Control parameters, the P-GW/SCEF uses the configured APN Rate Control parameters after the first APN Rate Control validity period expires, and sends an update to the UE with the configured APN Rate Control parameters.
4	P-GW sends CSRes to S-GW. P-GW prepares and encodes the APN Rate Control parameter into PCO/ePCO and sends back to S-GW in CSRes message with APN Rate Control parameters and Additional APN rate control parameters for exception data.
5	S-GW forwards the information (received from P-GW in Step 4) to MME.

APN Rate Control Parameter encodes information about Uplink time-unit and the Uplink rate supported.

8	7	6	5	4	3	2	1	
Spare				AER	Uplink time-unit			Octet 1
Maximum uplink rate								Octet 2 to Octet 4

Additional APN Rate control parameter for exception data encodes information about Uplink time-unit and the Uplink rate that is supported for the additional exception data.

8	7	6	5	4	3	2	1	
Spare					Uplink time-unit			Octet 1
Additional uplink rate for exception data								Octet 2 to Octet 3

Where Uplink Time-unit can take the value of any one as shown in the following format.

Uplink time-unit (Octet 1)	
Bit	
3 2 1	
0 0 0	Unrestricted
0 0 1	Minute
0 1 0	Hour
0 1 1	Day

1 0 0	Week

Maximum uplink rate (Octet 2 to Octet 4) is a binary coded representation of the maximum number of messages the UE is restricted to and sent per time-unit. If the uplink time-unit is set to "unrestricted", the maximum uplink data volume the UE can send is not restricted.

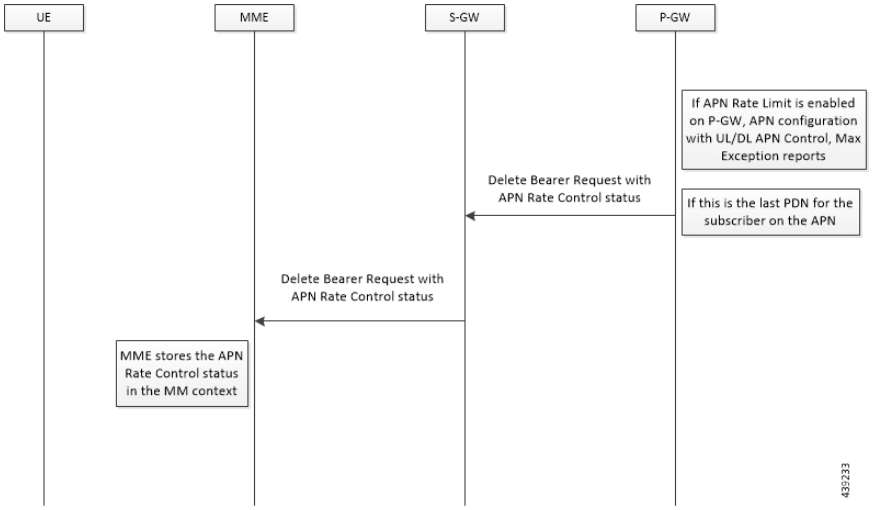
P-GW informs MME about UL APN Rate Control information in APN Rate Control Parameter, which is later stored by MME in MM context.

P-GW side APN Rate Control is based on “Maximum Allowed Rate” per direction. If P-GW provided the “number of additional allowed exception report packets per time unit” to the UE, then the "maximum allowed rate" is equal to the “number of packets per time unit” plus the “number of additional allowed exception report packets per time unit”. Otherwise, the “maximum allowed rate” is equal to the “number of packets per time unit”.

The P-GW enforces the uplink rate by discarding or delaying packets that exceed the “maximum allowed rate”. The P-GW enforces the downlink rate by discarding or delaying packets that exceed the downlink part of the “maximum allowed rate”.

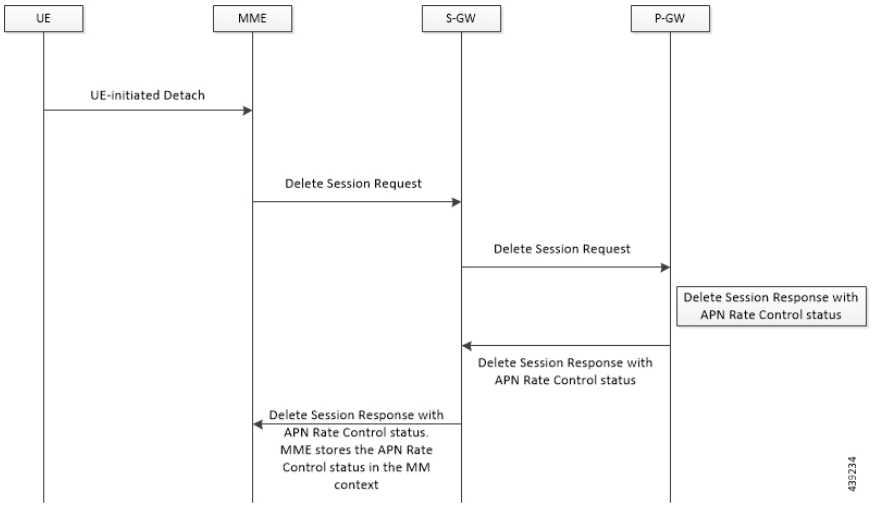
APN Rate Control Handling at P-GW on DBReq

On bearer deletion, if P-GW detects the current bearer is going to be the last bearer in the PDN for that specified APN, then it includes the APN Rate control status to MME through S-GW with the current quota of the rate limiting values (remaining messages on the remaining time-unit).



APN Rate Control Parameters on DSRes

On receiving the DSReq, P-GW clears the subscribers and sends the APN Rate Control status in CSRes with the remaining quota of the time and the messages for the subscriber to MME to update its MM context.



Licensing

The APN Rate Control for CIoT Devices is a license-controlled feature. Contact your Cisco Account representative for more information.

Standards Compliance

The APN Rate Control for CIoT Devices feature complies with the following standards:

- 3GPP TS 29.274 v15.8.0 - 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3
- 3GPP TS 23.401 v15.7.0 - General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access

Limitations and Considerations

The APN Rate Control for CIoT Devices feature has the following limitations and restrictions:

- This feature takes highest priority and checks if the rate limit is done before checking for any other feature.
- Both uplink and downlink rate limit take same time-unit (unlimited, minute, hour, day, or week) value. It never accepts different values.
- Applicable for P-GW and Collapsed calls.
- Applicable only for CIoT subscribers; check on RAT Type is done to identify the CIoT subscribers.
- Applicable only for the CIoT IP PDNs. This feature is not applicable for Non-IP PDNs.
- In case of reattach, P-GW sends the CSRes with APN Rate Control parameters which are remaining for the subscriber to UE to perform Uplink Rate control operation. On time-unit expiry, P-GW renews its quota, but it never shares the updated quota values to UE. UE gets the P-GW configured APN Rate Control values only at initial attach.

- If Virtual-APN concept is applied on the subscriber, the Gi-APN Rate Control parameters are considered.

Configuring the APN Rate Control for CIoT Devices Feature

Use the following configurations to enable the feature.

```
configure
  context context_name
    apn apn_name
      iot-rate-control time-unit { unrestricted | mins | hours | days |
 week } downlink packet-count dl_packet_count uplink packet-count ul_packet_count
 aer aer_value
      end
```

NOTES:

- **time-unit { unrestricted | mins | hours | days | week }**: Specifies the mode of time-unit.
- **downlink**: Applies the APN Rate Control in the downlink direction.
- **packet-count** *dl_packet_count*: Specifies the allowed number of downlink packets. The *dl_packet_count* must be an integer ranging from 0 through 16777215. Integer 0 disables rate control on the downlink direction.
- **uplink**: Applies the APN Rate Control in the uplink direction.
- **packet-count** *ul_packet_count*: Specifies the allowed number of uplink packets. The *ul_packet_count* must be an integer ranging from 0 through 16777215. Integer 0 disables rate control on the uplink direction.
- **aer** *aer_value*: Specifies the number of Additional Exception Reports (AER) in the uplink direction. The *aer_value* must be an integer ranging from 1 through 65535.
- If previously configured, use the **no iot-rate-control** CLI command to disable the feature.

Monitoring and Troubleshooting the APN Rate Control for CIoT Devices Feature

This section describes the CLI commands available to monitor and/or troubleshoot the feature.

Show Command Support

The following show CLI commands are available in support of the feature.

show apn statistics

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CIoT APN Rate Control:
  - Dropped UL packets: Displays the total number of APN Rate Control uplink packets that are dropped.

- Dropped DL packets: Displays the total number of APN Rate Control downlink packets that are dropped.
- Dropped UL bytes: Displays the total number of APN Rate Control uplink bytes that are dropped.
- Dropped DL bytes: Displays the total number of APN Rate Control downlink bytes that are dropped.

show session subsystem facility sessmgr all debug-info

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CIoT APN Rate Control
  - Dropped UL packets: Displays the total number of APN Rate Control uplink packets that are dropped.
  - Dropped DL packets: Displays the total number of APN Rate Control downlink packets that are dropped.
  - Dropped UL bytes: Displays the total number of APN Rate Control uplink bytes that are dropped.
  - Dropped DL bytes: Displays the total number of APN Rate Control downlink bytes that are dropped.

show subscriber full all

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CIoT APN Rate Control:
  - Allowed UL limit: Displays the number of packets allowed for uplink direction.
  - Allowed DL limit: Displays the number of packets allowed for downlink direction.
  - Remaining UL limit: Displays the number of packets remaining for uplink direction.
  - Remaining DL limit: Displays the number of packets remaining for downlink direction.
  - Allowed Time unit: Displays the time-unit configured in either unrestricted, minutes, hours, days, or week mode.
  - Status Validity Time: Displays the validity time in YYYY-MM-DD HH:MM:SS format.

Bulk Statistics

This section provides information on the bulk statistics for the APN Rate Control for CIoT Devices feature.

APN Schema

The following bulk statistics are available in the APN schema in support of the APN Rate Control for CIoT Devices feature.

Bulk Statistics	Description
apn-rate-control-ul-pkt-drop	Indicates the total number of APN Rate Control uplink packets that are dropped.

Bulk Statistics	Description
apn-rate-control-dl-pkt-drop	Indicates the total number of APN Rate Control downlink packets that are dropped.
apn-rate-control-ul-bytes-drop	Indicates the total number of APN Rate Control uplink bytes that are dropped.
apn-rate-control-dl-bytes-drop	Indicates the total number of APN Rate Control downlink bytes that are dropped.

Accounting Support

The following table provides details of the GTPP dictionary available in support of the APN Rate Control for CIoT Devices feature.

CDR Dictionaries/Fields	
Type of dictionary change (New/Modified):	Modified
Dictionary name:	P-GW custom24 GTPP dictionary
Based on (3GPP specification):	3GPP TS 32.299
Applicable record type(s):	G-CDR
Applicable product:	P-GW

The following CDR fields are introduced in the P-GW custom24 GTPP dictionary:

1. Field name: datapacketsFBCDownlink
   - Description: Downlink Packets count
   - Format: Integer
   - CLI command to configure the field: **gtpp fbc-downlink-pkt-cnt**
   - Default value for field: 0
2. Field name: datapacketsFBCUplink
   - Description: Uplink Packets count
   - Format: Integer
   - CLI command to configure the field: **gtpp fbc-uplink-pkt-cnt**
   - Default value for field: 0