



# LTE-M RAT Type Support on SAEGW, P-GW, and S-GW Services

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## Feature Summary and Revision History

### Summary Data

|  |  |
|--|--|
| Applicable Product(s) or Functional Area | <ul style="list-style-type: none"> <li>• S-GW</li> <li>• P-GW</li> <li>• SAEGW</li> </ul>  |
| Applicable Platform(s)                   | <ul style="list-style-type: none"> <li>• ASR 5500</li> <li>• VPC-DI</li> <li>• VPC-SI</li> </ul>   |
| Default Setting                          | Enabled-Always-On  |
| Related Changes in This Release          | Not Applicable   |
| Related Documentation                    | <ul style="list-style-type: none"> <li>• <i>Command Line Interface Reference</i></li> <li>• <i>P-GW Administration Guide</i></li> <li>• <i>S-GW Administration Guide</i></li> <li>• <i>SAEGW Administration Guide</i></li> </ul> |

**Revision History**

| Revision Details  | Release |
|-------------------|---------|
| First introduced. | 21.24   |

## Feature Description

LTE-M (LTE-MTC low-power-wide area (LPWA)) is a new cellular radio access technology specified by 3GPP that addresses low power-wide area connectivity solutions. It specifically refers to a specific category of LTE UEs that are suitable for IoT LTE-M, which supports IoT through lower device complexity and provides extended coverage, while allowing the reuse of the LTE installed base.

The RAT type IE is present in various call flows across many interfaces. When a Create Session Request is received with an unknown RAT Type, as the RAT Type is a Mandatory IE in this message, S-GW or P-GW may reject a create session request. In this StarOS 21.24 release, LTE-M RAT (Radio Access Technology) type for S-GW, P-GW, and SAEGW products are supported.

The RAT type is present either as an IE (for example, in GTPv2-C, GTPP), AVP (on Diameter-based interfaces) or as an attribute (for example in EDRs) across many interfaces.

The LTE-M solution for S-GW, P-GW, and SAEGW supports the following new LTE-M RAT type attribute value in the following Interfaces protocols and dictionaries:

- GX-interface: Diameter Protocol
- GY-interface: Diameter Protocol
- GZ/RF- interface: GTPP/Diameter/Radius
- S6B- Interface: Diameter Protocol
- S11/ S5/S8-Interface: GTPv2-C
- Dictionaries Radius AVPs, and dictionaries.
- Rf interface for CDR generation
- Attributes in EDRs

**Enhancements to the Existing Features**

The following existing features are enhanced to support the new RAT-TYPE LTE-M.

- **Virtual APN Selection Based on RAT Type:** Virtual APNs allow differentiated services within a single APN. The Virtual APN feature allows a carrier to use a single APN to configure differentiated services. The APN that is supplied by the MME is evaluated by the P-GW with multiple configurable parameters. Then, the P-GW selects an APN configuration based on the supplied APN and those configurable parameters. APN configuration dictates all aspects of a session at the P-GW, where different policies imply different APNs.

You can select the virtual APN by configuring directly under the base APN. This APN selection is done based on RAT Types. In this release, support is added through CLI to select the virtual APN for the LTE-M RAT type.

- **Qci and Qos Mapping:** P-GW supports QCI and QoS mapping association with APN based on RAT type LTE-M. This QCI and QoS mapping allow you to perform quick actions on the QoS Class Index (QCI) to QoS Mapping Configuration Mode, which is used to map QoS Class Indexes to enforceable QoS parameters. Mapping can occur in Serving Gateway (S-GW), and/or the PDN Gateway (P-GW) in an LTE network.
- **PCRF-based Handling:** P-GW informs the RAT type changes to PCRF through Credit Control Request -Initial and Updated messages, and PCRF provides a new PCC rule. Allows you to create a Bearer by enforcing a new Policy and Charging Control (PCC) rule from Policy and Charging Rules Function (PCRF).

# How it Works

## Architecture

The following table specifies the field and its value for various interfaces with support of LTE-M RAT type. Only Standard dictionaries and customized dictionaries are modified.

Table 1:

| Interface           | Field                            | Product | Message       | Value   |
|---------------------|----------------------------------|---------|---------------|---|
| <b>P-GW Product</b> |                                  |         |               |   |
| x                   | RAT-Type (1032)<br>Diameter      | M       | E T<br>7001 ( | Credit Control Request-Initial<br>• Credit Control Request - Updated                  |
| y                   | 3GPP-RAT-Type (21M)<br>Diameter  | M       | E T<br>9 (    | Credit Control Request-Initial<br>• Credit Control Request - Updated                  |
| SUBCDR              | RAT-Type (21M)                   | M       | E T<br>9 (    | Accounting Request -Start<br>• Accounting Request- Stop<br>• Account request -Interim |
| f                   | 3GPP-RAT-Type (21M)<br>Diameter  | M       | E T<br>9 (    | Accounting Request -Start<br>• Accounting Request- Stop<br>• Account request -Interim |
| b                   | 3GPP-RAT-Type (1032)<br>Diameter | M       | E T<br>9 (    | Authentication<br>• Authorisation<br>• Request  |

| ca           | File          | P  | Messages           |
|--------------|---------------|----|--------------------|
|              |               | et | rt                 |
|              |               |    | A                  |
| s            | RAT-Type      | M  | ETL                |
|              |               | )  | 9 (                |
| W            | RAT-Type (30) | M  | ETL                |
| S            | R.D.C         | )  | 9 (                |
|              | GTPP          |    | • Transfer Request |
| S-GW Product |               |    |                    |
| s            | RAT-Type (30) | M  | ETL                |
|              |               | )  | 9 (                |
|              |               |    | • Transfer Request |

## Limitations

Following are the known limitations for new LTE-M RAT type feature:

- Rule matching at ECS
- Ruledef matching at Local-Policy

## Supported Standards

Cisco's implementation of the LTE RAT type complies with the following standards:

- 3GPP 23.401 – eGTPC Interface
- 3GPP 29.274 Release 15.4.0 – 3GPP GTPv2 Protocol Specification Reference table for LTE-M Rat type support; RAT Type IE details are given in the following table for egtpc IEs encoding and decoding :
  - Table 7.2.1-1: Information Elements in a Create Session Request
  - Table 7.2.7-1: Information Elements in a Modify Bearer Request
  - Table 7.2.7-1: Information Elements in a Modify Bearer Request
- 3GPP 23.401 Release 15.4.0 – 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access
- 3GPP 32.299 Release 15.4.0 – 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Policy and Charging Control (PCC).
- 3GPP 29.060 – 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp interface.
- 3GPP 29.061 – 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)

- 3GPP 32.298 – 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Charging management; Charging Data Record (CDR) parameter description
- 3GPP 29.212 Release 15.4.0 – 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Policy and Charging Control (PCC).

## Configuring Virtual-APN

Use the following configuration to display an additional option (LTE-M) “RAT-Type” based Virtual-APN selection .

```
configure
  context context_name
    apn apn_name
      virtual-apn preference value apn apn_name rat-type lte-m
    end
```

### NOTES:

- **apn** *apn\_name*: Allows to specify the APN name as a condition. *apn\_name* must be an alphanumeric string of 1 through 63 characters.
- **virtual-apn preference** *value* **apn** *apn\_name* : Configures the virtual-apn (virtual.ipv4).
- **rat-type lte-m**: Enables LTE-M as an additional RAT-type.

## Configuring qci-qos-mapping

Use the following configuration to configure QCI-QOS mapping in the APN Configuration mode and associate additional RAT type (LTE-M).

```
configure
  context context_name
    apn apn_name
      qci table
        qci-qos-mapping
          qci qci_val non-gbr { downlink user-datagram dscp-marking value
        }
      end
```

### NOTES:

- **apn** *apn\_name*: Allows to specify the APN name as a condition. *apn\_name* must be an alphanumeric string of 1 through 63 characters.
- **qci-qos-mapping**: Configures the qci-qos-mapping for APN.
- **qci** *qci\_val*: Specifies the QoS Class Identifier. *qci\_val* must be an integer between 1 to 9, 80, 82, and 83.
  - **downlink**: Specifies the direction of traffic on which this QoS configuration needs to be applied.

### Associate Qci-Qos-Mapping

Use the configuration to select the qci-qos-mapping RAT Type.

```

configure
  context context_name
    apn apn_name
      associate qci-qos-mapping table rat-type lte-m
    end

```

#### NOTES:

- **associate qci-qos-mapping table rat-type lte-m** : Associates apn qci-qos-mapping based on the RAT type.

## Monitoring and Troubleshooting

This section provides information regarding commands available to monitor and troubleshoot the LTE-M RAT Type support on the SAEGW, P-GW and S-GW Services.

### Show Commands and Output

This section provides information on show commands and their corresponding outputs for the LTE-M RAT type feature.

#### show apn name

The following output is displayed if the Virtual-APN is selected based on the RAT-Type, during the Session-Setup.

##### Output:

```

show apn name <>
Virtual APN Configuration:
  Preference  Selected-APN          Rule-Definition
  10          verizon.ipv4          CC Profile Index = 3
  RAT Type = lte-m [local]qvmc-si# show configuration

```

#### show apn all

The output of **show apn all** and **show apn name apn\_name all** commands has been enhanced to monitor the APN configuration for qci-qos-mapping on RAT type **lte-m**:

##### Example:

```

show apn name <>
qci-qos-mapping Name for RAT-Type:
GERAN :N/A          UTRAN :N/A
EUTRAN : N/A       LTE-M : table
Stats Profile Name : N/A

```

#### show qci-qos-mapping table all

Following example is the sample output before associating the qci-qos-mapping table based on additional RAT Type (LTE-M).

```

QCI-QOS Table Name: table

Qci: 1
uplink: n/a
downlink: user-datagram          dscp-marking 0x3e
maximum packet delay: n/a        maximum error rate: n/a
delay class: n/a                  precedence class: n/a
reliability class: n/a           qci type: non-gbr
volte: n/a                        traffic policing interval: n/a

Qci: 2
uplink: n/a
downlink: internal-qos priority 1
maximum packet delay: n/a        maximum error rate: n/a
delay class: n/a                  precedence class: n/a
reliability class: n/a           qci type: gbr
volte: n/a                        traffic policing interval: n/a

```

## show configuration

The **virtual-apn preference** *value apn apn\_name rat-type lte-m* output is displayed when the Virtual APN is configured with the LTE-M RAT type. Following is the sample output:

```

[local]qvpc-si# show configuration
apn intershat
  pdp-type ipv4 ipv6
  bearer-control-mode mixed
  selection-mode subscribed sent-by-ms chosen-by-sgsn
  accounting-mode radius
  ims-auth-service ims-ggsn-auth
  ip access-group acl4-1 in
  ip access-group acl4-1 out
  authentication pap 1 chap 2 allow-noauth
  ip context-name egress
  virtual-apn preference 10 apn verizon.ipv4 rat-type lte-m
  ipv6 access-group acl6-1 in
  ipv6 access-group acl6-1 out
  active-charging rulebase prepaid
exit

```

Similarly, the **associate qci-qos-mapping table rat-type lte-m** output is displayed for the qci-qos association changes based on RAT type. Following is the sample output

```

[local]laas-setup# show configuration
  apn intershat
  context ingress
  subscriber default
  nexthop-forwarding-address
  exit
  apn intershat
  associate qci-qos-mapping table rat-type lte-m
  exit

```

## show subscribers full

The output of this show command is used for monitoring the subscriber call. The RAT type of the call is displayed as LTE-M. A new field **LTE-M** is added under Access Technology. Following is the sample output:

```

[local]laas-setup# show subscribers all
Access (X) - CDMA 1xRTT (E) - GPRS GERAN (I) - IP
|| Tech: (D) - CDMA EV-DO (U) - WCDMA UTRAN (W) - Wireless LAN
|| (A) - CDMA EV-DO REVA (G) - GPRS Other (M) - WiMax

```

**show subscribers full all**

```

||                (C) - CDMA Other          (J) - GAN          (O) - Femto IPsec
||                (P) - PDIF                (S) - HSPA        (L) - eHRPD
||                (T) - eUTRAN              (B) - PPPoE       (F) - FEMTO UTRAN
||                (N) - NB-IoT              (Q) - WSG         (R) - LTE-M
||                (.) - Other/Unknown

```

**show subscribers full all**

The output of the following show commands are used for monitoring the subscriber call. The Access Technology of the call is displayed as LTE-M.

```

Username: 9890098900          Status: Online/Active
Access Type: sgw-pdn-type-ipv4-ipv6   Network Type: IPV4+IPV6
Access Tech: LTE-M             Access Network Peer ID: n/a
callid: 02fb3ea1              msid: 404005123456789
Card/Cpu: 1/0                 Sessmgr Instance: 11
state: Connected
connect time: Tue Mar 23 04:33:55 2021 call duration: 00h00m46s
idle time: 00h00m40s          idle time left: n/a

```

**show subs pgw-only full / show subs pgw-only full all**

The **show subs pgw-only full / show subs pgw-only full all** commands display the Access Technology of the call as LTE-M. Following is the sample output:

```

Access Type: gtp-pdn-type-ipv4-ipv6   Network Type: IPV4+IPV6
Access Tech: LTE-M                    pgw-service-name: PGW21
Callid: 02fb3ea2                     IMSI: 404005123456789
MSISDN: 9890098900                   External ID: n/a
Interface Type: S5S8GTP               Low Access Priority: N/A
TWAN Mode: N/A
eMPS Bearer: No
Emergency Bearer Type: N/A
IMS-media Bearer: No
S6b Auth Status: N/A

```

**show subs sgw-only full / show subs sgw-only full all**

The **show subs sgw-only full / show subs sgw-only full all** commands display the Access Technology of the call as LTE-M. Following is the sample output:

```

Card/Cpu          : 1/0          Sessmgr Instance : 11
Idle time         : 00h05m47s
MS TimeZone       : n/a          Daylight Saving Time: n/a

Access Type: sgw-pdn-type-ipv4-ipv6   Network Type: IPV4+IPV6
Access Tech: LTE-M                     sgw-service-name: SGW21
Callid: 02fb3ea1                       IMSI: 404005123456789
MSISDN: 9890098900
eMPS Bearer: No

```

**show subs saegw-only full / show subs saegw-only full all**

The **show subs saegw-only full / show subs saegw-only full all** commands display the Access Technology of the call as LTE-M. Following is the sample output:

```

Callid   : 02fb3ea3          IMSI           : 404005123456789
Card/Cpu : 1/0              Sessmgr Instance : 11
Source context : EPC2       Destination context : ISP1
Bearer Type  : Default      Bearer-Id       : 5
Access Type  : gtp-pdn-type-ipv4-ipv6   Network Type     : IPV4+IPV6

```



```

Access Tech      : LTE-M                      saegw-service-name : SAEGW21
MSISDN          : 9890098900                 External ID         : n/a
TWAN Mode       : N/A
eMPS Bearer     : No
WPS Bearer      : No

```

## show subs pgw-only all

The **show subs pgw-only all** command displays the following output:

```

|+-----Access      (U) - UTRAN      (G) - GERAN
||      Tech:      (W) - WLAN              (J) - GAN
||              (U) - HSPA Evolution    (E) - eUTRAN
||              (H) - eHRPD              (.) - Unknown
||              (N) - NB-IoT            (R) - LTE-M

```

## show subs sgw-only all

The **show subs sgw-only all** command displays the following output:

```

|+----Access      (U) - UTRAN  (G) - GERAN              (W) - WLAN
||      Tech:      (J) - GAN          (S) - HSPA Evolution (E) - eUTRAN
||              (.) - Unknown          (N) - NB-IoT        (R) - LTE-M
||

```

## show subs saegw-only all

The **show subs saegw-only all** command displays the following output:

```

|+----Access      (U) - UTRAN  (G) - GERAN              (W) - WLAN
||      Tech:      (J) - GAN          (S) - HSPA Evolution (E) - eUTRAN
||              (H) - eHRPD          (.) - Unknown        (N) - NB-IoT
||              (R) - LTE-M

```

## show subscribers callid

The **show subscribers callid** *callid* command displays the Access Technology of the call as LTE-M. Following is the sample output:

```

|+----Access      (X) - CDMA 1xRTT (E) - GPRS GERAN      (I) - IP
||      Tech:      (D) - CDMA EV-DO          (U) - WCDMA UTRAN    (W) - Wireless LAN
||              (A) - CDMA EV-DO REVA      (G) - GPRS Other    (M) - WiMax
||              (C) - CDMA Other           (J) - GAN           (O) - Femto IPsec
||              (P) - PDIF                 (S) - HSPA         (L) - eHRPD
||              (T) - eUTRAN               (B) - PPPoE        (F) - FEMTO UTRAN
||              (N) - NB-IoT               (Q) - WSG          (R) - LTE-M
||
||              (.) - Other/Unknown

```

## show session subsystem

The following output displays the session related statistics:

```

LTE-M Data Statistics
    0 Total Sessions                0 Total calls arrived
    0 Total calls connected          0 Total calls disconnected
NB-IoT Connection Statistics
    0 Total Sessions                0 Total calls arrived
    0 Total calls connected          0 Total calls disconnected
LTE-M Connection Statistics

```

**show session subsystem verbose**

```

0 Total Sessions                0 Total calls arrived
0 Total calls connected         0 Total calls disconnected

```

Similarly, the **show session subsystem full** is enhanced to display the Data packets and subscribers count per RAT type.

**show session subsystem verbose**

The **show session subsystem verbose** command displays the following output:

```

NB-IoT Data Statistics
    packets to User:           0    octets to User:   0
    packets from User:         0    octets from User:  0

LTE-M Data Statistics
    packets to User:           0    octets to User:   0
    packets from User:         0    octets from User:  0

NB-IoT Connection Statistics
0 Total Sessions                0 Total calls arrived
0 Total calls connected         0 Total calls disconnected

LTE-M Connection Statistics
0 Total Sessions                0 Total calls arrived
0 Total calls connected         0 Total calls disconnected

```

**show session summary**

The **show session summary** command displays the following output:

```

4G LTE (EUTRAN): 0
2G (GERAN): 0
3G (UTRAN): 0
WiFi (WIRELSS LAN): 0
eHRPD: 0
3G HA: 0
NB-IoT: 2
LTE-M: 0
Others: 0

```

**show subscribers subscription full**

The **show subscribers subscription full** command displays the following output:

```

Username: 9890098900          Status: Online/Active
Access Type: sgw-pdn-type-ipv4-ipv6    Network Type: IPV4+IPV6
Access Tech: LTE-M            Access Network Peer ID: n/a
callid: 02fb3ea1             msid: 404005123456789
Card/Cpu: 1/0                Sessmgr Instance: 11
state: Connected
connect time: Wed Mar 17 09:59:47 2021 call duration: 00h01m19s
idle time: 00h01m13s          idle time left: n/a
session time left: n/a

```

**show subscribers activity all**

The **show subscribers activity all** command displays the Access Technology of the call as LTE-M. Following is the sample output:

```

Username: 9890098900          Status: Online/Active
Access Type: sgw-pdn-type-ipv4-ipv6    Network Type: IPV4+IPV6

```

Access Tech: LTE-M  
callid: 02fb3eal

Access Network Peer ID: n/a  
msid: 404005123456789

## show apn statistics all-name

The show output command displays the statistics per APN and also displays number of initiated sessions and active sessions with LTE-M RAT Type per APN. Following is the sample output:

```
Initiated Sessions per RAT Type:
  EUTRAN: 0      UTRAN: 0
  GERAN: 0      EHRPD: 0
  S2A GTP: 0    S2B GTP: 0
  S2B PMIP:0    NB-IoT: 0
  LTE-M : 0
```

```
Active Sessions per RAT Type:
  EUTRAN: 0    UTRAN: 0
  GERAN: 0    WLAN: 0
  HSPA: 0     NB-IoT:0
  LTE-M: 0    OTHER: 0
```

## show saegw-service statistics all-name

The show output command displays the statistics per SAEGW service and also displays Current subscribers, the Current PDNs with NB-IoT RAT Type per SAEGW Service. Following is the sample output:

```
Current Subscribers By RAT-Type:
  EUTRAN:                0      UTRAN:                0
  GERAN:                 0      NB-IoT:               0
  LTE-M:                 0      OTHER:                0

Current PDNs By RAT-Type:
  EUTRAN:                0      UTRAN:                0
  GERAN:                 0      NB-IoT:               0
  LTE-M:                 0      OTHER:                0
```

## show pgw-service statistics all-name

The show output command displays statistics for each P-GW Services, the number of initiated PDNs, and current PDNs with NB-IoT RAT Type for each P-GW Services. Following is the sample output:

```
Initiated PDNs By RAT-Type:
  EUTRAN:                0      UTRAN:                0
  GERAN:                 0      EHRPD:                0
  S2A GTP:               0      S2B GTP:              0
  S2B PMIP:              0      NB-IoT:               0
  LTE-M                   0

Current PDNs By RAT-Type:
  EUTRAN:                0      UTRAN:                0
  GERAN:                 0      WLAN:                 0
  NB-IoT:                0      LTE-M                 0
  OTHER:                 0
```

## show sgw-service statistics

This show command displays statistics for each S-GW Services. This CLI is enhanced to display Current Subscribers and Current PDNs with NB-IoT RAT type for each S-GW Services. Following is the sample output:

```

Current Subscribers By RAT-Type:
  EUTRAN: 0      UTRAN: 0
  GERAN:  0      NB-IoT: 0
  LTE-M:  0      OTHER:  0
Current PDNs By RAT-Type:
  EUTRAN: 0      UTRAN: 0
  GERAN:  0      NB-IoT: 0
  LTE-M:  0      OTHER:  0

```

## Bulk Statistics

The following statistics are added in support of the LTE-M RAT type feature

### APN Schema

The following LTE-M RAT type feature-related bulk statistics are available in the APN schema.

| Bulk Statistics          | Description  |
|--------------------------|--|
| active-lte-m-sessions    | The total number of active LTE-M sessions per APN with RAT type LTE-M. |
| initiated-lte-m-sessions | The total number of initiated LTE-M sessions.                          |

### P-GW Schema

The following LTE-M RAT type feature related bulk statistics available in the P-GW schema.

| Bulk Statistics         | Description   |
|-------------------------|---|
| sesstat-pdn-rat-lte-m   | The total number of active PDN Type Statistics – LTE-M.         |
| sessstat-rat-init-lte-m | The total number of initiated LTE-M PDNs (with RAT Type LTE-M). |

### S-GW Schema

The following LTE-M RAT type feature related bulk statistics available in the S-GW schema.

| Bulk Statistics           | Description  |
|---------------------------|--|
| sessstat-totcur-ue-lte-m  | The total number of active UEs with LTE-M RAT type.  |
| sessstat-totcur-pdn-lte-m | The total number of active PDNs with LTE-M RAT type. |

### SAEGW Schema

The following LTE-M RAT type feature related bulk statistics available in the SAE-GW schema.

| Bulk Statistics                 | Description  |
|---------------------------------|--|
| sgw-sessstat-totcur-ue-lte-m    | The total number of active UEs with LTE-M RAT type.                              |
| sgw-sessstat-totcur-pdn-lte-m   | The total number of LTE-M PDNs (PGW anchored/Collapsed PDN) with RAT Type LTE-M. |
| pgw-sesstat-pdn-rat-lte-m       | The total number of LTE-M PDNs (PGW anchored/Collapsed PDN) with RAT Type LTE-M. |
| pgw-sessstat-pdn-rat-init-lte-m | The total number of initiated LTE-M PDNs.  |
| saegw-sgw-anchor-pdn-rat-lte-m  | The total number of LTE-M PDNs (SGW anchored) with RAT Type LTE-M.               |
| saegw-pgw-anchor-pdn-rat-lte-sm | The total number of LTE-M PDNs (PGW anchored) with RAT Type LTE-M.               |
| saegw-collapsed-pdn-rat-lte-m   | The total number of LTE-M PDNs (PGW anchored/Collapsed PDN) with RAT Type LTE-M. |

