

Closed Subscriber Groups

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Feature Description

The MME provides support for Closed Subscriber Groups (CSG). This enables the MME to provide access control and mobility management for subscribers who are permitted to access one or more CSG cells of the PLMN as a member of the CSG for a Home eNodeB (HeNB).

A CSG ID is a unique identifier within the scope of the PLMN which identifies a Closed Subscriber Group in the PLMN associated with a CSG cell or group of CSG cells.

The MME performs access control for CSG a UE will not be permitted to access the network through a CSG cell unless either the UE's subscription data includes the same CSG ID as the CSG cell, or if the CSG cell is operating in hybrid mode. The MME also optionally reports the UE's CSG information to the S-GW/P-GW, based on the MME's CLI mme-service configuration. The S-GW/P-GW, in turn, informs the MME when it should report user CSG information.

How It Works

Closed Subscriber Group functionality is comprised of three main components, each are described in this section.

- Access Control, on page 1
- CSG Notification to S-GW/P-GW, on page 3
- CSG Status Communication to Peer MME/SGSN, on page 4

Access Control

The MME performs CSG-based access control by examining the CSG cell information provided by the eNodeB through the S1AP interface for a UE connection or handover attempt, and comparing that to the CSG subscription data for that UE provided by the HSS through the S6a interface. CSG-based access control affects the following S1AP and S6a messages and messaging:

S1AP Messaging



Important For additional security, the S1AP connections between the MME and the eNBs may be secured through IPSec.

- **S1 Setup Request** If the eNB sending the S1 Setup Request supports one or more CSG cells, the S1 Setup Request will contain the CSG IDs of the supported CSGs. The MME will store the CSG IDs as part of the data pertaining to the eNB.
- **eNB Configuration Update** If the eNB sending the eNB Configuration Update supports one or more CSG cells, the eNB Configuration Update will contain the CSG IDs of the supported CSGs, which may or may not have changed from those sent in the S1 Setup Request. The MME will overwrite the stored CSG IDs for that eNB with the list contained in the eNB Configuration Update.
- **Initial UE Message** If the establishment of the UE-associated logical S1-connection is performed due to a connection originating from a CSG cell, the CSG ID is included in the Initial UE Message. If the establishment of the UE-associated logical S1-connection is performed due to a connection originating from a Hybrid cell, the CSG ID and the Cell Access Mode IE are included in the Initial UE Message. The MME stores the CSG ID and Cell Access Mode in the UE context. If the UE context already exists, the MME overwrites the existing CSG ID and Cell Access Mode with the new data, or clears the CSG ID and Cell Access Mode if the CSG ID is not present in the message. The CSG ID is checked against the subscription data from the HSS to determine if the UE is a member of the CSG. If the UE is not a member, and the cell is not a hybrid cell, access is denied.
- **Initial Context Setup Request** If the cell is a hybrid cell, the Initial Context Setup Request from the MME contains a CSG Membership Status IE indicating whether the UE is a member of the cell's CSG.
- **UE Context Modification Request** A UE Context Modification Request from the MME contains a CSG Membership Status IE if the cell has a CSG ID (if the cell is either a CSG cell or a hybrid cell). The MME sends a UE Context Modification Request indicating CSG Membership Status is Non-member if the HSS sends a Delete Subscriber Data Request with DSR Flags indicating that CSG subscription data is being deleted. The MME also sends a UE Context Modification Request indicating CSG Membership Status is Non-member if the CSG subscription data for the CSG in question includes an Expiration Date AVP and the time indicated by the AVP has been reached.
- **Paging** The Paging message may contain a list of one or more CSG IDs. If the MME includes this list, the eNodeB avoids paging the UE at CSG cells whose CSG ID does not appear in the list. If the UE has CSG IDs in its subscription data, the MME includes the intersections of the eNodeB's CSG ID list and the subscriber's CSG ID list in the Paging message whenever that UE is being paged.
- **Handover Required** The Handover Required message may contain a CSG ID if it does, there may also be a Cell Access Mode IE which indicates the target cell is a hybrid cell. When the MME receives a Handover Required message with a CSG ID, it uses the UE's subscription data to determine if the UE is a member of the CSG in question. If the UE is not a member and the cell is not a hybrid cell, the MME refuses the handover attempt. Otherwise, the MME conveys the CSG information to the target system.
- **Handover Request** If the MME is sending a Handover Request message, a CSG ID is included in the message if the target has been specified as either a CSG cell or hybrid cell with the CSG ID in question. If the cell has been specified as a hybrid cell, the MME also includes a CSG Membership Status IE in the Handover Request as well.
- **Handover Request Ack** If the Handover Request contains both a CSG ID and a CSG Membership Status IE, but the target cell in question is a hybrid cell that broadcasts a different CSG ID, the actual CSG ID

of the cell shall be included in the Handover Request Ack. Upon receipt of such a message, the MME changes the CSG ID of the UE, marks the target cell as being a hybrid cell, and considers the UE to be a non-member of the CSG. Note that the MME may later discover via subscription data from the HSS that the UE is actually a member of the CSG in question if so, it sends a UE Context Modification Request indicating that the UE is a member of the CSG. Note also that if the Handover Request contains a CSG ID and the target cell broadcasts a different CSG ID and is not a hybrid cell, the eNB sends a Handover Failure message, not a Handover Request Ack.

S6a Messaging

- **Update Location Ack** Messages from the HSS contain the UE's subscription data, which may include CSG subscription data. CSG subscription data consists of one or more CSG IDs, each of which may also have an associated expiration date. The CSG IDs are interpreted within the context of the PLMN ID sent to the HSS in the Visited-PLMN-ID AVP in the Update Location Request message. The CSG subscription data is stored in the UE's database entry along with the rest of the UE subscription data. The MME stores up to eight CSG IDs per UE. The MME uses the CSG subscription data to determine membership in a given CSG by comparing the CSG ID of the current cell against the CSG IDs in the subscription data.
- **Delete Subscriber Data Request** The HSS can indicate to the MME to delete the stored CSG subscription data by sending a Delete Subscriber Data Request message with the CSG Deleted bit set in the DSR flags. If this happens, and the UE is currently connected to a cell where it was a CSG member, the MME sends a UE Context Modification Request indicating that the UE is no longer a CSG member. The MME is responsible for enforcing the expiration date (if any) for a given CSG as indicated in the CSG subscription data. If the CSG subscription expires, the MME must send a UE Context Modification Request indicating that the UE is no longer a CSG member.

CSG Notification to S-GW/P-GW

The MME informs the P-GW whether it supports CSG change notification by setting the CSG Change Reporting Support Indication (CCRSI) flag. MME support for CSG change notification can be enabled or disabled. If it is enabled, the P-GW, based on input from the PCRF, determines if CSG change notification is required by sending the CSG Information Reporting Action IE to the MME.

CSG notification to the S-GW/P-GW affects the following S11 messages and messaging:

- **Create Session Request** The Indication IE in the Create Session Request contains a CSG Change Reporting Support Indication (CCRSI) flag, which is set when the MME is configured to support CSG information change reporting to the S-GW/P-GW. If the UE is attached through a CSG or hybrid cell, the User CSG Information (UCI) IE is be included in the Create Session Request. The User CSG Information IE contains the PLMN and CSG ID of the CSG or hybrid cell in question, the access mode (closed or hybrid), and if the access mode is hybrid, the membership status of the UE in the CSG.
- **Create Session Response** The P-GW/S-GW will send the CSG Reporting Information IE in the Create Session Response if CSG information reporting is to be started or stopped. This IE includes three bits that indicate whether the MME should report when the UE enters or leaves a CSG (non-hybrid) cell, a subscribed hybrid cell, or an unsubscribed hybrid cell. If all three bits are set to zero, all CSG information reporting to the S-GW/P-GW is stopped. The MME stores the CSG reporting information as part of the PDN context, since the reporting requirements may be different on different P-GWs.
- **Create Bearer Request** The Create Bearer Request message from the P-GW/S-GW may include a CSG Reporting Information IE if CSG reporting from the MME is to change. The MME stores the CSG reporting information as part of the PDN context in question.

- **Modify Bearer Request** The CCRSI flag in the Indication IE is set in a Modify Bearer Request when the MME is configured to support CSG information change reporting to the S-GW/P-GW. If the P-GW/S-GW has requested CSG information reporting and a TAU, Handover, or UE-initiated Service Request is taking place, the MME includes the User CSG Information IE in the Modify Bearer Request message.
- **Update Bearer Request** The Update Bearer Request message from the P-GW/S-GW may include a CSG Reporting Information IE if CSG reporting from the MME is to change. The MME stores the CSG reporting information as part of the PDN context in question.
- **Change Notification Request** The MME sends a Change Notification Request to the S-GW/P-GW for each PDN where it is requested, if a change to the CSG connection information changes without requiring either a Create Bearer Request or Modify Bearer Request. The Change Notification Request contains a User CSG Information IE. Since Location Reporting also uses the Change Notification Request message, the MME minimizes the number of Change Notification Request messages sent by bundling the reporting of a location change with a CSG change into the same message whenever possible.
- **Change Notification Response** The Change Notification Response message from the P-GW/S-GW may include a CSG Reporting Information IE if CSG reporting from the MME is to change. The MME stores the CSG reporting information as part of the PDN context in question.

CSG Status Communication to Peer MME/SGSN

The MME indicates its ability to report location information using the "CSG Change Reporting Support Indication" which is a part of the indication flags parameter.

CSG status communication to a peer MME or SGSN affects the following S10 and S3 messages and messaging:

- **Forward Relocation Request** If the source MME or SGSN supports CSG information change reporting, the CCRSI flag is set in the Indication IE in a Forward Relocation Request message from that MME or SGSN. If the source eNB or RNC included a target CSG ID as part of the Handover Required message, the source MME or SGSN include that CSG ID in a CSG ID IE in the Forward Relocation Request. If the source eNB or RNC indicated that the target cell is a hybrid cell, the source MME or SGSN determine whether the UE is a member of the CSG and include the CSG Membership Indication IE in the Forward Relocation Request. (A Forward Relocation Request that contains a CSG ID IE but no CSG Membership Indication IE indicates that the target cell is a closed CSG cell.) The PDN Connection IE(s) in the Forward Relocation Request will contain a CSG Information Reporting Action IE if the P-GW/S-GW had previously sent it to the source MME or SGSN for the PDN in question.
- **Context Response** If the old MME or SGSN in a Context Request/Response/Ack exchange supports CSG information change reporting, the CCRSI flag is set in the Indication IE shall be set in the Context Response from that MME or SGSN. The PDN Connection IE(s) in the Context Response contains a CSG Information Reporting Action IE if the P-GW/S-GW had previously sent it to the old MME or SGSN for the PDN in question.

Message Flows

The following diagram shows the messaging between the EPC elements in a Closed Subscriber Group implementation.

Figure 1: Closed Subscriber Groups Message Flow

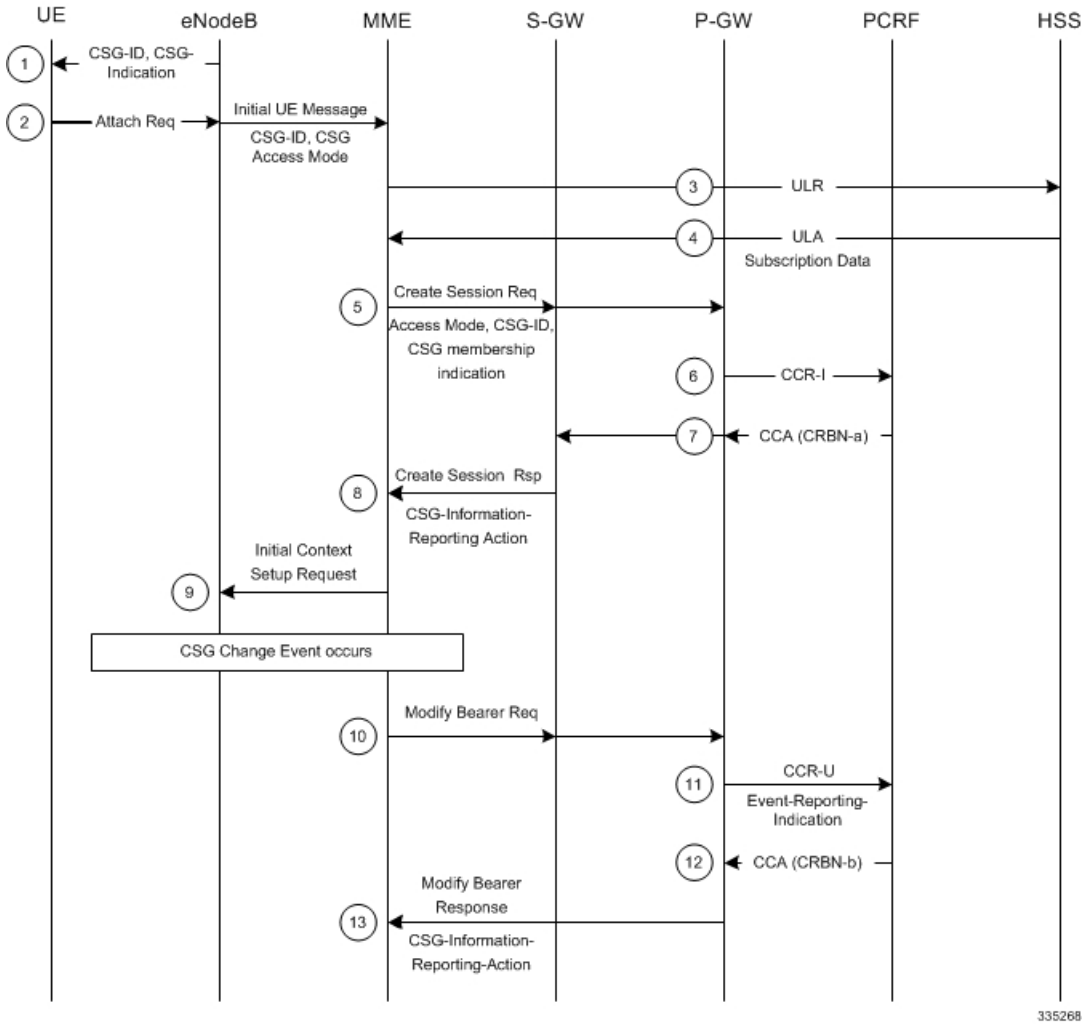


Table 1: Closed Subscriber Groups Message Flow 0

Step	Description
1	The eNodeB broadcasts the CSG Information to UEs.
2	When an Attach Request event happens, the eNodeB sends its own CSG-related Information in Initial UE message to the MME.
3	The MME sends an Update Location Request (ULR) to the HSS to get subscriber's profile.
4	The HSS responds with an Update Location Answer (ULA) including Subscription-Data which includes CSG-Subscription-Data. If the ULA does not include a CSG_ID: 1) The Attach attempt will be rejected if the Access mode is set to Closed 2) The call will proceed on a non-CSG-member basis if the Access mode is set to Hybrid.
5	The MME proceeds with the call according to the user profile from the HSS. The MME sets the CSG membership Indication and passes it to the S-GW including Access Mode and CSG-ID. The S-GW transparently passes the information to the P-GW.

Step	Description
6	The P-GW requests policy and charging rule from the PCRF.
7	The PCRF sends Event-Trigger:=USER_CSG_INFO_CHG and USER-CSG-INFO AVP based on user subscription profile.
8	The P-GW sets CSG-Information-Reporting-Action in Create Session Response when the P-GW receives Event-Trigger:=USER_CSG_INFO_CHG.
9	The MME sends CSG-Membership-Status to eNodeB. This is only occurs when the Access mode is set to Hybrid.
10	When a CSG change event happens, the eNodeB/MME reports the event. The MME updates CSG change event using a Change Notification Request or Modify Bearer Request.
11	The P-GW reports CSG change event using Event-Reporting-Indication AVP to the PCRF.
12	The PCRF updates the policy and charging rule with Charging-Rule-Base-Name or install new Charging-Rule-Base-Name.
13	The P-GW sends a CSG Information Reporting Action IE as part of the Modify Bearer Response, a Change Notification Response, or it can initiate a change through an Update Bearer Request.

Configuring Closed Subscriber Groups

CSG access control and status communication to peer MMEs/SGSNs is mandatory and enabled by default. CSG notification to the S-GW/P-GW is optional and may be enabled using the **csg-change-notification** CLI command within the scope of the mme-service configuration.

Use the following example to enable CSG change notification to the S-GW/P-GW.

```
configure
  context context_name
    mme-service mme_svc_name -noconfirm
      csg-change-notification
      end
```

Notes:

- By default, **csg-change-notification** is disabled and the MME does not send CSG notification to the S-GW/P-GW.

Verifying the Closed Subscriber Groups Configuration

Use either of the following Exec mode commands to verify if CSG notification to the S-GW/P-GW is enabled.

```
show mme-service all
```

```
show mme-service name mme_svc_name
```

The output of these commands displays the entire configuration for either all the MME services or just for the one specified. The output sample below only illustrates the line used to indicate the Closed Subscriber Groups (CSG) configuration status.

```
show mme-service name mmesvc1
CSG Change Notification              : Enabled
```

Monitoring and Troubleshooting Closed Subscriber Groups

CSG information and per-PDN CSG reporting information is included the following Exec mode command.

show mme-service session full all

The sample output below shows only the information relating to CSG.

```
show mme-service session full all
      CSG Cell Change Notification:  Enabled
            CSG Subscribed Hybrid Cell Change Notification:  Enabled
            CSG Unsubscribed Hybrid Cell Change Notification:  Enabled
      CSG Information:
            CSG ID at last connection: 15625 (0x3d09)
      CSG cell type: Hybrid
      CSG membership status: Non-Member
```

If the CSG cell is not a hybrid cell, the CSG Information section will be displayed as follows:

```
      CSG Information:
            CSG ID at last connection: 15625 (0x3d09)
      CSG cell type: Closed
      CSG membership status: Member
```

If the last (or current) cell is not a CSG cell, the CSG Information section will be displayed as follows:

```
      CSG Information:
            CSG ID at last connection: None
      CSG cell type: n/a
      CSG membership status: n/a
```

The following command shows CSG IDs from the subscription data:

show mme-service db record imsi imsi_id

```
      show mme-service db record imsi 123456789012345
      CSG IDs                 : 10
                                25
                                625
```

If no CSG IDs are present in the subscription data, that state will be displayed as follows:

```
      CSG IDs                 : None
```

The following command shows statistics for the number of times the MME sent a NAS message with the cause value "Not authorized for this CSG". These statistics are tracked for Attach Reject, Detach Request, Service Reject, and TAU Reject.

The sample output that follows shows only the statistics relating to CSG.

show mme-service statistics

```
      show mme-service statistics
Attach Reject:                      0
      ...
      CSG Not Subscribed:               0
Detach Request:                      0
      ...
      CSG Not Subscribed:               0
Service Reject:                      0
      ...
      CSG Not Subscribed:               0
TAU Reject:                     0
```

```
...
CSG Not Subscribed:               0
```