



Heuristic and Intelligent Paging

This chapter describes the advanced paging features of the MME.

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Feature Description

A valid license key is required to enable heuristic and intelligent paging. Contact your Cisco Account or Support representative for information on how to obtain a license.

The MME supports two levels of paging optimization to minimize the paging load in the E-UTRAN access network:

- **Heuristic Paging**

Also known as idle-mode paging, this optimized paging feature reduces network operations cost through more efficient utilization of paging resources and reduced paging load in the E-UTRAN access network. This problem is acute in the radio access network, where paging is a shared resource with finite capacity. When a request for an idle mode access terminal is received by the S-GW, the MME floods the paging notification message to all eNodeBs in the Tracking Area List (TAI). To appreciate the magnitude of the problem, consider a network with three million subscribers and a total of 800 eNodeBs in the TAI. If each subscriber was to receive one page during the busy hour, the total number of paging messages would exceed one million messages per second.

- **Intelligent Paging**

Intelligent Paging further optimizes heuristic paging to allow operators to specify different paging profiles for different streams of traffic (CS or PS traffic types). Each paging profile provides the flexibility to control the pace, volume and type of paging requests sent to eNBs.

How It Works

Heuristic Paging

Each MME maintains a list of "n" last heard from eNodeBs for the UE. The intent is to keep track of the eNodeBs that the AT commonly attaches to such as the cells located near a person's residence and place of work. During the average day, the typical worker spends the most time attaching to one of these two locations.

Using Heuristic Paging, the MME attempts to page the user in stages as described in the "Heuristic Paging Behavior" section that follows.

Default (Non-Heuristic) Paging Behavior

If no license is in place, or if the heuristic paging is not turned on, the MME by default pages all eNodeBs in all TAIs present in the TAI list assigned to the UE.

The number of paging retries attempted for Packet Switch (PS) calls is dictated by the **max-paging-attempts** command under the mme-service configuration. If no configuration exists then by default 3 retries are attempted.

The timeout duration for each retry is dictated by the **t3413-timeout** command under mme-service configuration. If no configuration exists, the default value of 6 seconds is used.

For Circuit Switch (CS) calls, the MME sends only one paging attempt, regardless of the configuration of the **max-paging-attempts** command.

Heuristics Paging Behavior

If heuristics paging is turned on for the mme-service the following heuristics paging behavior can be observed for Circuit Switched (CS) and Packet Switched (PS) events, the Default Heuristics Paging refers to Heuristics paging without an associated paging map:

The default Heuristics paging behavior for CS events like SGS PAGING (Voice ,SMS), MM INFO and so on is listed below:

- Page all eNodeBs in all TAIs present in the TAI list assigned to the UE.

The default Heuristics paging behavior for PS events like DDN, Create Bearer Request, Delete Bearer request ,Update Bearer Request and so on is listed below:

- 1 Page the last eNodeB from which the UE contacted the MME in the last TAI from which the UE contacted the MME.
- 2 Page all eNodeBs in the last TAI from which the UE contacted the MME.
- 3 Page all eNodeBs in all TAIs present in the TAI list assigned to the UE.

When heuristic paging is enabled, the MME tracks the last TAI from which the UE contacted the MME and the last eNodeB from which the UE contacted the MME.

Paging to the last eNodeB (1) and the TAI from which UE was last heard (2) is done only once. **max-paging-attempts** configured in the mme-service is used only to control the number paging attempts to all eNodeBs in all TAIs (3).

**Important**

For paging requests for circuit switch (CS) calls, the MME does not follow this staged paging behavior. Instead, it follows the standards-defined paging mechanism of paging all eNodeBs in all TAIs present in the TAI list assigned to the UE (all-enb-all-tai). Only one attempt is made with no retries.

Intelligent Paging

With Intelligent Paging, the MME can be configured with paging profiles which define different stages of paging (paging maps). These controls determine whether the MME sends a paging-request to either the last TAI or all TAIs. In addition, these controls determine whether the MME sends the paging request to just one eNodeB, a specific number of eNodeBs, or to all eNBs. This enables the MME to control the span and reach of each paging request.

Two modules, configurable under the LTE Policy configuration mode, are introduced to support intelligent paging:

- **Paging-profile** -- This module allows operator to configure different stages of paging in the order of desired execution with parameters that control the pace, volume and behavior of a given paging stage.
- **Paging-map** -- This module allows operator to apply different 'paging-profiles' to different traffic types. When MME service is associated with an instance of this module, MME checks this map object to figure the type of paging-profile to adopt for a given paging trigger.

**Important**

If the MME is associated with a paging-map object that either does not exist or does not have an entry matching the paging-trigger, the MME performs paging as described in *Default Heuristics Paging Behavior*.

Configuring MME Paging Features

**Important**

Use of these Paging features require that a valid license key be installed. Contact your local Sales or Support representative for information on how to obtain a license.

Configuring Heuristic Paging

The example configuration in this section allows the MME to perform heuristic (optimized), idle-mode paging, reducing the number of messages carried over the E-UTRAN access network.

The following configuration example enables heuristic (optimized) paging on the MME:

```
configure
  context <mme_context_name>
    mme-service <mme_svc_name>
      heuristic-paging
    end
```

Configuring Intelligent Paging

The following sections provide configuration examples to enable intelligent paging on the MME:

-
- Step 1** Create and configure a **paging-profile**.
 - Step 2** Create and configure a **paging-map**.
 - Step 3** Enable heuristic paging and assign a paging-map to a specific mme-service.
-

Creating and Configuring the Paging-Profile

A paging-profile enables operators to configure different stages of paging in the order of desired execution with parameters that control the pace, volume and behavior of a given paging stage.

The following configuration example creates two paging-profiles in the lte-policy configuration mode:

```
configure
  lte-policy
    paging-profile <paging_profile_name1> -noconfirm
      paging-stage 1 match-criteria all action all-enb-all-tai t3413-timeout 5 max-paging-attempts
4
    exit
    paging-profile <paging_profile_name2> -noconfirm
      paging-stage 1 match-criteria all action last-n-enb-last-tai max-n-enb 1 t3413-timeout 5
max-paging-attempts 1
      paging-stage 2 match-criteria all action all-enb-last-tai t3413-timeout 5 max-paging-attempts
1
    end
```

Creating and Configuring the Paging-Map

A paging-map enables operators to apply different paging-profiles to different traffic types. When an MME service is associated with an instance of this module, the MME checks this map object to figure the type of paging-profile to adopt for a given paging trigger.

The following configuration example creates a paging-profile in the LTE Policy configuration mode:

```
configure
  lte-policy
    paging-map <paging_map_name> -noconfirm
      precedence 1 traffic-type { cs | ps } paging-profile paging_profile_name1
    end
```

Beginning in Release 16.0, the paging-map configuration includes additional configuration options for selecting a paging-profile in order to control the pace, volume and behavior of a given paging state. Within a paging map, precedence can be defined for paging requests based on the following traffic types:

- CS traffic (circuit-switched traffic for Mobile Terminated CSFB) types can be defined according to specific subtypes of **voice**, **sms**, and **other**.

- PS traffic (packet-switched traffic for all data and control messaging that involve packet services as well as IMS Voice) types can be defined according to the QoS **QCI value** from the EPS Bearer ID (EBI) in the Downlink Data Notification (DDN) received on S11 from the S-GW. The ARP priority based paging can be defined for PS traffic.
- **Signaling** (UE-level signaling requests) traffic types can also be defined. This option can be further qualified with the **Detach** and **LCS** (Location Services) traffic subtype options.

These options are shown in the following **precedence** command syntax:

```
precedence precedence traffic-type { cs [ voice | sms | other ] | ps [ qci qci_value ] | signaling | detach | lcs ] } paging-profile paging_profile_name
```

From release 20.0 onwards the **precedence** command has been enhanced as follows:

```
precedence priority traffic-type { cs [ voice | sms | other ] | ps [ arp arp_value | qci qci_value ] | signaling [ detach | idr | lcs | node-restoration ] } paging-profile paging_profile_name
```

Refer to the *LTE Paging Map Configuration Commands* chapter of the *Command Line Interface Reference* for more information about this command.

Enable Heuristic Paging with Paging-Map (Intelligent Paging)

The following example enables heuristic-paging and associates a paging-map to the specified MME service.

```
configure
  context <mme_context_name> -noconfirm
    mme-service <mme_svc_name> -noconfirm
      heuristic-paging paging-map paging_map_name
    end
```

Verifying the Paging Configuration

The following command displays the entire paging configuration for the MME service.

```
show mme-service all
```

The output of the above command will be similar to the following:

```
[local]asr5x00 show mme-service name mmesvc1
Heuristic Paging      : Enabled
Heuristic Paging Map  : pgmap1
```

Monitoring and Troubleshooting the MME Paging Features

For more information regarding bulk statistics and output fields and counters in this section, refer to the *Statistics and Counters Reference*.

Paging Bulk Statistics

The following bulk statistics are included in the MME Schema to track paging events:

- ps-qci-1-paging-init-events-attempted
- ps-qci-1-paging-init-events-success

- ps-qci-1-paging-init-events-failures
- ps-qci-1-paging-last-enb-success
- ps-qci-1-paging-last-tai-success
- ps-qci-1-paging-tai-list-success
- ps-qci-2-paging-init-events-attempted
- ps-qci-2-paging-init-events-success
- ps-qci-2-paging-init-events-failures
- ps-qci-2-paging-last-enb-success
- ps-qci-2-paging-last-tai-success
- ps-qci-2-paging-tai-list-success
- ps-qci-3-paging-init-events-attempted
- ps-qci-3-paging-init-events-success
- ps-qci-3-paging-init-events-failures
- ps-qci-3-paging-last-enb-success
- ps-qci-3-paging-last-tai-success
- ps-qci-3-paging-tai-list-success
- ps-qci-4-paging-init-events-attempted
- ps-qci-4-paging-init-events-success
- ps-qci-4-paging-init-events-failures
- ps-qci-4-paging-last-enb-success
- ps-qci-4-paging-last-tai-success
- ps-qci-4-paging-tai-list-success
- ps-qci-5-paging-init-events-attempted
- ps-qci-5-paging-init-events-success
- ps-qci-5-paging-init-events-failures
- ps-qci-5-paging-last-enb-success
- ps-qci-5-paging-last-tai-success
- ps-qci-5-paging-tai-list-success
- ps-qci-6-paging-init-events-attempted
- ps-qci-6-paging-init-events-success
- ps-qci-6-paging-init-events-failures
- ps-qci-6-paging-last-enb-success
- ps-qci-6-paging-last-tai-success

- ps-qci-6-paging-tai-list-success
- ps-qci-7-paging-init-events-attempted
- ps-qci-7-paging-init-events-success
- ps-qci-7-paging-init-events-failures
- ps-qci-7-paging-last-enb-success
- ps-qci-7-paging-last-tai-success
- ps-qci-7-paging-tai-list-success
- ps-qci-8-paging-init-events-attempted
- ps-qci-8-paging-init-events-success
- ps-qci-8-paging-init-events-failures
- ps-qci-8-paging-last-enb-success
- ps-qci-8-paging-last-tai-success
- ps-qci-8-paging-tai-list-success
- ps-qci-9-paging-init-events-attempted
- ps-qci-9-paging-init-events-success
- ps-qci-9-paging-init-events-failures
- ps-qci-9-paging-last-enb-success
- ps-qci-9-paging-last-tai-success
- ps-qci-9-paging-tai-list-success
- cs-voice-paging-init-events-attempted
- cs-voice-paging-init-events-success
- cs-voice-paging-init-events-failures
- cs-voice-paging-last-enb-success
- cs-voice-paging-last-tai-success
- cs-voice-paging-tai-list-success
- cs-sms-paging-init-events-attempted
- cs-sms-paging-init-events-success
- cs-sms-paging-init-events-failures
- cs-sms-paging-last-enb-success
- cs-sms-paging-last-tai-success
- cs-sms-paging-tai-list-success
- cs-other-paging-init-events-attempted
- cs-other-paging-init-events-success

- cs-other-paging-init-events-failures
- cs-other-paging-last-enb-success
- cs-other-paging-last-tai-success
- cs-other-paging-tai-list-success
- signaling-detach-paging-init-events-attempted
- signaling_detach-paging-init-events-success
- signaling-detach-paging-init-events-failures
- signaling-detach-paging-last-enb-success
- signaling-detach-paging-last-tai-success
- signaling-detach-paging-tai-list-success
- signaling-lcs-paging-init-events-attempted
- signaling_lcs-paging-init-events-success
- signaling-lcs-paging-init-events-failures
- signaling-lcs-paging-last-enb-success
- signaling-lcs-paging-last-tai-success
- signaling-lcs-paging-tai-list-success

Release 15.0: The following bulk statistics are included in the MME Schema to track paging events. Note that these bulk statistics have been replaced by the bulk statistics above.

- ps-paging-init-events-attempted
- ps-paging-init-events-success
- ps-paging-init-events-failures
- ps-paging-last-enb-success
- ps-paging-last-tai-success
- ps-paging-tai-list-success

Release 20.0

The following bulk statistics are included in the MME schema in for eMPS support :

- slap-transdata-pagingpriocs
- slap-transdata- pagingpriops
- csfb-ue-prio-voice-total
- csfb-ue-prio-voice-success
- csfb-ue-prio-voice-failures
- csfb-nw-prio-voice-total
- csfb-nw-prio-voice-success

- csfb-nw-prio-voice-failures
- ps-arp-1-paging-init-events-attempted
- ps-arp-1-paging-init-events-success
- ps-arp-1-paging-init-events-failures
- ps-arp-1-paging-last-enb-success
- ps-arp-1-paging-last-tai-success
- ps-arp-1-paging-tai-list-success
- ps-arp-2-paging-init-events-attempted
- ps-arp-2-paging-init-events-success
- ps-arp-2-paging-init-events-failures
- ps-arp-2-paging-last-enb-success
- ps-arp-2-paging-last-tai-success
- ps-arp-2-paging-tai-list-success
- ps-arp-3-paging-init-events-attempted
- ps-arp-3-paging-init-events-success
- ps-arp-3-paging-init-events-failures
- ps-arp-3-paging-last-enb-success
- ps-arp-3-paging-last-tai-success
- ps-arp-3-paging-tai-list-success
- ps-arp-4-paging-init-events-attempted
- ps-arp-4-paging-init-events-success
- ps-arp-4-paging-init-events-failures
- ps-arp-4-paging-last-enb-success
- ps-arp-4-paging-last-tai-success
- ps-arp-4-paging-tai-list-success
- ps-arp-5-paging-init-events-attempted
- ps-arp-5-paging-init-events-success
- ps-arp-5-paging-init-events-failures
- ps-arp-5-paging-last-enb-success
- ps-arp-5-paging-last-tai-success
- ps-arp-5-paging-tai-list-success
- ps-arp-6-paging-init-events-attempted
- ps-arp-6-paging-init-events-success

- ps-arp-6-paging-init-events-failures
- ps-arp-6-paging-last-enb-success
- ps-arp-6-paging-last-tai-success
- ps-arp-6-paging-tai-list-success
- ps-arp-7-paging-init-events-attempted
- ps-arp-7-paging-init-events-success
- ps-arp-7-paging-init-events-failures
- ps-arp-7-paging-last-enb-success
- ps-arp-7-paging-last-tai-success
- ps-arp-7-paging-tai-list-success
- ps-arp-8-paging-init-events-attempted
- ps-arp-8-paging-init-events-success
- ps-arp-8-paging-init-events-failures
- ps-arp-8-paging-last-enb-success
- ps-arp-8-paging-last-tai-success
- ps-arp-8-paging-tai-list-success
- ps-arp-9-paging-init-events-attempted
- ps-arp-9-paging-init-events-success
- ps-arp-9-paging-init-events-failures
- ps-arp-9-paging-last-enb-success
- ps-arp-9-paging-last-tai-success
- ps-arp-9-paging-tai-list-success
- ps-arp-10-paging-init-events-attempted
- ps-arp-10-paging-init-events-success
- ps-arp-10-paging-init-events-failures
- ps-arp-10-paging-last-enb-success
- ps-arp-10-paging-last-tai-success
- ps-arp-10-paging-tai-list-success
- ps-arp-11-paging-init-events-attempted
- ps-arp-11-paging-init-events-success
- ps-arp-11-paging-init-events-failures
- ps-arp-11-paging-last-enb-success
- ps-arp-11-paging-last-tai-success

- ps-arp-11-paging-tai-list-success
- ps-arp-12-paging-init-events-attempted
- ps-arp-12-paging-init-events-success
- ps-arp-12-paging-init-events-failures
- ps-arp-12-paging-last-enb-success
- ps-arp-12-paging-last-tai-success
- ps-arp-12-paging-tai-list-success
- ps-arp-13-paging-init-events-attempted
- ps-arp-13-paging-init-events-success
- ps-arp-13-paging-init-events-failures
- ps-arp-13-paging-last-enb-success
- ps-arp-13-paging-last-tai-success
- ps-arp-13-paging-tai-list-success
- ps-arp-14-paging-init-events-attempted
- ps-arp-14-paging-init-events-success
- ps-arp-14-paging-init-events-failures
- ps-arp-14-paging-last-enb-success
- ps-arp-14-paging-last-tai-success
- ps-arp-14-paging-tai-list-success
- ps-arp-15-paging-init-events-attempted
- ps-arp-15-paging-init-events-success
- ps-arp-15-paging-init-events-failures
- ps-arp-15-paging-last-enb-success
- ps-arp-15-paging-last-tai-success
- ps-arp-15-paging-tai-list-success

Paging Show Command(s) and/or Outputs

This section provides information regarding show commands and/or their outputs in support of the MME Paging features.

Only those counters which relate to paging are shown.

The following command displays a list of all paging-profiles in ordered by the paging-stage.

show lte-policy paging-profile summary

The following command shows information for the specified paging-profile.

show lte-policy paging-profile name <name >

```
[local]asr5x00 show lte-policy paging-profile name pg-aggressive
```

```

Paging Profile : pg-aggressive
Paging Stage 1 :
  Paging Action      - Page all TAIs in all ENBs.
  Match Criteria    - No conditions. Always apply this stage.
  T3414-Timeout     - 5 sec
  Max Paging Retries - 4

```

The following command shows a list of all paging-maps configured.

show lte-policy paging-map summary

The following command shows information for the specified paging-map.

show lte-policy paging-map name < name >

```

[local]asr5x00 show lte-policy paging-map name pg-map2
Paging Map : pg-map2
  Precedence 1 : Circuit-Switched (CS); Paging is performed as per paging-profile
pg2
  Precedence 2 : Packet-Switched (PS); Paging is performed as per paging-profile
pg4

```

The following command shows the UE Tracking Information for the Last Reported 5 eNodeBs and Last Reported 7 ECGIs for the specified IMSI.

show mme-service db record imsi < imsi >

The following command shows information about the Paging Initiation Events.

show mme-service statistics

The following groups of PS paging initiation event counters track individual events for each QCI level (1-7).

The following sample shows only the fields for QCI-1. Additional groups of fields are provided for QCI-2 through QCI-7.

```

Paging Initiation for PS QCI-1 Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0

```

The following groups of CS traffic paging event counters events based on sub-traffic type: (CS **Voice** Events, CS **SMS** Events, and CS **Other** Events) .

```

Paging Initiation for CS Voice Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0
Paging Initiation for CS SMS Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0
Paging Initiation for CS Other Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0

```

The following groups of Signaling event counters track individual Detach and LCS (Location Services) paging events.

```

Paging Initiation for SIGNALING DETACH Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0
Paging Initiation for SIGNALING LCS Events:
  Attempted: 0   Success: 0
  Failures: 0
  Success at Last n eNB: 0   Success at Last TAI: 0
  Success at TAI List: 0

```