

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**

  Paging is a shared resource with a finite capacity in the radio access network. 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). A network has several million customers and hundreds of eNodeBs in the TAI. If each subscriber receives a page during peak network traffic hour, more than a million number of paging messages are generated per second. In order to prevent this scenario, Heuristics or Idle-mode paging is introduced. 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. In heuristics paging the MME keeps track of the eNodeB to which the UE most commonly attaches or was previously connected to and only pages those eNodeBs before paging the TA or TA (Tracking Area) list, thus reducing the signaling otherwise associated with continuous paging.

  When heuristics paging is enabled, MME selects the paging profile based on the APN profile, if paging-profile with matching APN profile name is fetched from the APN information corresponding to the EBI received in DDN is configured in the paging-map. If the incoming DDN does not have the EBI information then the APN information is received from the bearers stored in the MME for the UE. If multiple APN information is available then the mapping with the highest precedence is picked. MME warns the user of duplicate APN profile names in a given entry. The same APN profile name cannot be configured with more than one precedence level.

- **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

The MME 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** keyword in the **emm** command under the mme-service configuration mode . If the keyword is not configured, 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 enabled for the mme-service the following heuristics paging behavior is observed:

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. Heuristic paging is disabled by default.

When Heuristic Paging is enabled, it applies only to messages sent to all eNodeBs in all TAIs present in the TAI list. Paging to the last known eNodeB and paging the TAI from which the UE was last heard is attempted only once. As a result, when **max-paging-attempts** is set to 3, a maximum of 5 paging retries are attempted with Heuristic Paging enabled



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:

Procedure

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

```
configure
    paging-map <paging_map_name > -noconfirm
     precedence 1 traffic-type { cs | ps } paging-profile paging_profile_name

      end
```

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) type 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) type can be qualified using a set of QCI values or ARP values or APN profile names. These qualified entries are only used for paging triggered by S11 Downlink Data Notifications or Create Bearer Request or Update Bearer Request.

- **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
```

The **precedence** command has been enhanced as follows:

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

The paging profile with the highest precedence is selected when QCI, ARP and APN Profile, all are configured in the paging-map. If no QCI, ARP and APN-Profile specific mapping exists then the default 'PS' traffic type configuration in the paging-map will be picked and the paging-profile corresponding to that mapping is used. If a paging trigger is received while a paging procedure is on-going, and if the new paging trigger has a higher precedence (considering QCI, ARP or APN-profile configuration mapping) then the paging-profile corresponding to that will be used in the next paging retry. One precedence level can be configured with only one of, QCI or ARP or APN-Profile name, at any point of time.

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:

```
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 :

- s1ap-transdata-pagingpriocs
- s1ap-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

The following new bulk statistics are added in the MME schema to support APN-based paging differentiation:

- ps-apn-profile-paging-init-events-attempted – The total number of ECM statistics-related PS Paging Initiation Events that were attempted. It is incremented for APN-Profile event.
- ps-apn-profile-paging-init-events-success – The total number of ECM statistics-related PS Paging Initiation Events that were successful. It is incremented for APN-Profile event.
- ps-apn-profile-paging-init-events-failures – The total number of ECM statistics-related PS Paging Initiation Events that Failed. It is incremented for APN-Profile event.
- ps-apn-profile-paging-last-enb-success – The total number of ECM Statistics-related PS Paging Initiation Events that succeeded at the last known eNodeB. It is incremented for APN-Profile event.
- ps-apn-profile-paging-last-tai-success – The total number of ECM Statistics-related PS Paging Initiation Events that succeeded at an eNodeB in the TAI from which the UE was last heard. It is incremented for APN-Profile event.
- ps-apn-profile-paging-tai-list-success – The total number of ECM Statistics-related PS Paging Initiation Events that succeeded at an eNodeB in all TAIs present in the TAI list assigned to the UE. It is incremented for APN-Profile event.

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* **>**

```
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* **>**

```
      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
            Precedence 3 : Packet-Switched (PS) APN : pg5; Paging is performed as per
paging-profile pg5
```

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 counters track paging events for PS APN-Profile based selection.

```
Paging Initiation for PS APN-Profile based selection:
    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
```